UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

MEMORANDUM

SUBJECT: Impact Estimates from Proposed and Revised Pollinator Labeling for Representative Blooming Agricultural Crops Utilizing Commercial Pollination Services

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SUMMARY

In May, 2015, EPA's Office of Pesticide Programs (OPP) proposed restrictions on bloom-time applications of pesticides that are moderately or highly acutely toxic (MHAT) to bees on crops that are pollinated under contract with commercial beekeepers. Since that time, OPP has received significant feedback and comments from stakeholders and the general public on the proposed restrictions. In this memorandum, OPP's Biological and Economic Analysis Division (BEAD) is providing preliminary estimates of the potential impact of such restrictions for a number of representative pilot crop scenarios, which were chosen to represent the diversity of the most important contract pollinated crops and crop groups grown in the United States: almonds, apples (which serve as a surrogate for all pome and stone fruits), caneberries, cranberries, strawberries, blueberries, cucurbits (various), sunflowers, and alfalfa grown for seed.

BEAD estimated impacts under 2 mitigation options. Option 1 is based upon the original proposal to restrict bloom time usage of active ingredients identified as MHAT to commercial bees on a hazard-based index. The relevant active ingredients for this analysis are listed in Appendix 1. Option 2 is a risk-based approach, where likely application rates were considered on a chemical by chemical basis and bloom-time restriction was based upon exceedance of OPP's established level of concern (LOC) for acute bee toxicity, which can vary by application rate. As a practical result, fewer active ingredients are restricted under option 2, meaning that some active ingredients that were restricted under option 1 may be available for usage in option 2 due to application rates that fall below OPP's pollinator LOC. Conversely, chemicals that were not on the initial MHAT listing would be prohibited when used at rates that exceed OPP's level of concern for acute toxicity to bees (however this situation did not arise in this analysis). BEAD assessed the likely substitution costs for alternative insecticides under both options, and also projected possible yield losses for cases where alternatives were either expected to be ineffective or unavailable.

On the whole, the magnitude of projected impacts is mainly driven by the likelihood of yield and/or quality losses. While pesticide substitution costs can be significant for some of the crops, these impacts are dwarfed by any potential loss of crop yield (or significant reductions in crop quality) that would result from an inability to control specific pests during bloom in the crops where BEAD concluded that such impacts could occur. BEAD's analysis concluded that yield losses were likely for crops with long periods of indeterminate bloom, and on the whole, such extended bloom times were the best predictor of high impacts driven by yield losses. As a result of this analysis, OPP's revised pollinator protection proposal will therefore include exemptions from proposed restrictions for crops that were projected to still have potential yield losses under option 2. These crops are: strawberries, cucurbits, and crops grown for seed, including sunflowers. Tables 47 and 48 (pp. 65-66) summarize the projected impacts for mitigation options 1 and 2, respectively. Additional crops may also include similar exemptions, due to the likelihood of indeterminate bloom leading to yield losses, based upon the assessments of the pilot crops in this analysis.

BACKGROUND

In June 2014, the President of the United States issued a Memorandum to promote the health of honey bees and other pollinators and to set out a strategy that addresses the multiple factors affecting honey bees and pollinator health, https://www.whitehouse.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b. The Memorandum explained the need to expand Federal efforts to reverse pollinator losses and calls for the development of new public-private partnerships across various sectors (state, tribal and local government, industry, and non-governmental organizations) to reverse pollinator losses and restore populations to healthy levels.

Consistent with this directive, OPP proposed additional mandatory restrictions on the labels of pesticide products to reduce the likelihood of acute exposure and mortality to managed bees. Managed bees include those for purposes of pollination services and honey production (i.e., honey bees, bumble bees, alfalfa leaf cutters, and blue orchard bees). Managed bees may be managed by hobbyists or commercial beekeepers. These restrictions would prohibit and/or limit applications of acutely toxic pesticide products (listed in Appendix 1) during bloom while bees are placed on site. The proposal built on EPA's earlier efforts to reduce the likelihood of acute exposure and mortality from neonicotinoid pesticides. The new mitigation measures would affect a large number of pesticides (most insecticides and some herbicides) determined to be acutely toxic to bees. After receipt of numerous public comments and submissions from varied stakeholders, OPP has reconsidered the scope of this policy by applying it only to product use scenarios that are indicated to exceed an acute risk level of concern (LOC; RQ ≥0.4) for honey bees (*Apis mellifera*). Further, OPP has decided, based on risk-benefit balancing, to permit exceptions to the mitigation language for certain crops, such as indeterminate blooming crops and crops where economic impact is expected to be high. For the purposes of BEAD's impact analysis, these exemptions from the bloom time restriction are not considered. Rather, the following analysis shows the justification for why exemptions were proposed for indeterminately blooming crops. The purpose of this memo is to compare the relative differences in projected impacts between these two options and to project which crops were still projected to see significant impacts from either or both options.

The scope of the proposed mitigation applies to all products (FIFRA Section 3 and 24(c) Special Local Need registrations) that have:

1) Liquid or dust formulations as applied;

2) Outdoor foliar use directions for pollinator-attractive agricultural crops, ornamentals under commercial production, or in public or commercial landscape settings; and,

3) Active ingredient(s) that have been determined via testing to have an acute toxicity value less than 11 micrograms per bee (LD50<11 µg/bee).[1] Such active ingredients are considered to be moderately to highly acutely toxic (MHAT) to bees. (OPP, 2016)

For chemicals that exceed OPP's levels of concern for acute honeybee toxicity at field rates, foliar applications of identified products would be prohibited from onset of flowering until flowering is complete when contracted pollinators are present at the treatment site. If contracted bees are not present during bloom time, a grower still has the option to use pesticides toxic to bees. Ultimately, OPP's final proposal reflects considerations driven by the high projected impacts of mitigation option 1 (i.e., off-labeling of products containing active ingredients listed in Appendix 1), which led to the development of mitigation option 2 (i.e., restricting bloom time usage based on specific risk-based criteria that take application rates into account).

[1] Based on the acute toxicity data requirement outlined in Title 40, Code of Federal Regulations §158.630[1] and include data generated through OCSPP Test Guideline 850.3020[1] or OECD Test Guideline 214[1] or by data deemed by EPA to be functionally equivalent

Purpose

The following analysis estimates the potential impacts that growers who contract with beekeepers for pollination services may incur under the new label requirements for active ingredients considered to be moderately to highly acutely toxic (MHAT) to bees. For growers using toxic pesticides during bloom on relevant crops, there are a number of decisions/outcomes that are possible. Growers can:

A) use an alternative product or combination of products that are applied foliarly but do not contain an active ingredient that is moderately or highly acutely toxic to bees;
B) use a product that is not applied foliarly (e.g., soil drench);
C) opt to make no application(s) of the chemical(s) at any time; or
D) make the application(s) outside the timeframe when flowering has onset to when flowering is complete.

In any of these cases, it is expected that a grower will incur impacts from reductions in yield or quality if pest control is compromised by switching to different pest management systems and/or increased cost of using alternative chemicals. The following analysis provides an overview of what some of these impacts might be using representative cropping scenarios for a number of crop groups. However, projected impacts are expected to vary across crops, regions, and cropping systems, and the results of this analysis represent only a general impact estimate that is intended to be representative for the crops most likely to be impacted by the published proposal.

Context and Qualification

In general, most growers of flowering crops already take steps to avoid making foliar spray applications during periods of bloom. In particular, growers who enter into contractual relationships with beekeepers for pollination services might be bound either by written or implied conditions of the contract that limit or discourage bloom-time applications while bees are present. For example, some contracts can be as strict as forbidding any pesticide applications while bees are on the premises, while other contracts simply require that the beekeeper be notified before a grower makes a pesticide application. Furthermore, some states have already established pollinator protection plans, which list best management practices and make recommendations for limiting exposure of honeybees to residue from pesticide applications, such as has been published for California almonds (California Almond Board, 2014). BEAD knows of no published extension publications in the United States for contract pollinated crops that currently recommend growers to use acutely toxic insecticides during bloom. However, localized pest outbreaks, weather conditions, or other mitigating circumstances sometimes make such applications difficult to avoid. The following contract pollinated crop scenarios evaluate what would be done in circumstances when these factors make bloom time spray applications necessary.

Proposals, Data, and Methodology

This analysis was conducted for two options under consideration by OPP, to contrast the likely impact outcomes:

Option 1 is the original OPP proposal published in May, 2015. Under this option, MHAT pesticides were identified based upon testing that determined LD-50 values for adult honeybees of (LD50<11 μg/bee).[2] Such active ingredients are considered to be moderately to highly acutely toxic (MHAT) to bees. For MHAT chemicals, foliar applications of identified products would be prohibited from onset of flowering until flowering is complete when contracted pollinators are present at the treatment site. Chemicals most affected by this approach are listed in Appendix 1.

Option 2 is based upon a chemical-by-chemical evaluation of risk to bees, using actual labeled application rates by crop. Rather than off-labeling an entire suite of MHAT chemicals, bloom-time prohibitions would apply for applications that exceed OPP's identified levels of concern (LOC) for acute honeybee toxicity at field rates. LOC's are derived from OPP's existing database of acute toxicity to adult honeybees. This means that some chemicals that would have been identified in OPP's original list of MHAT chemicals can be allowed during bloom if the application rate results in an acute bee exposure estimate that is below OPP's LOC. Conversely, chemicals that were not affected by the original proposal could be prohibited if a specific application rate results in an exposure estimate that exceeds the LOC (though this situation was not encountered in this analysis).

For both of these options, BEAD's analysis estimates the likely impacts to growers from having to modify their pest management approaches in accordance with the respective pollinator protection proposals. To assess impacts, BEAD estimated the costs from having to switch to an alternative, non-MHAT pesticide for pest control. BEAD identified the leading MHAT insecticides that are applied to foliage during bloom time by crop, identified the high-use MHAT chemicals for each crop based on acres treated, identified the major pests for each high-use MHAT insecticide, and identified the most likely non-MHAT alternatives. Data sources include usage and pesticide pricing information from pesticide Market Research Data (MRD) and represent average usage/prices over a 5-year period to account for typical variations that can occur year to year. State Agricultural Extension Guides were also consulted in determining appropriate alternatives that would be safe to foraging bees. For scenarios where no viable alternatives are available to growers during bloom, BEAD estimated yield and/or quality losses based upon publicly available information and expert opinion.

For each crop, BEAD's methodology progresses as follows:

1. Identify chemicals with the highest usage during bloom periods that are MHAT to bees.
2. Identify the main target pests for which these chemicals are used during bloom.
3. Identify available alternative chemicals that confer efficacy against these target pests that do not pose acute risk concerns to bees and different pest management strategies that could be employed to avoid bee exposure to toxic pesticides.
4. Compare the yield and/or quality outcomes of the alternative pesticides or pest management approaches to that of the toxic pesticides being restricted.
5. Estimate the total per-acre costs of using alternatives as well as the possibility of significant yield or quality losses due to lack of efficacious alternatives.

When analyzing total treated acreage for pesticides, it should be noted that multiple applications of an active ingredient (AI) to the same crop area during the same crop stage can result in double-counting of treated acreage. So throughout this analysis, any 'total' acreage figures given should be assumed to be an upper-bound estimate of total treated acreage and not necessarily a precise representation of the acres treated with a particular chemical.

[2] Based on the acute toxicity data requirement outlined in Title 40, Code of Federal Regulations §158.630[2] and include data generated through OCSPP Test Guideline 850.3020[2] or OECD Test Guideline 214[2] or by data deemed by EPA to be functionally equivalent

It should also be noted that in addition to honey bees (*Apis mellifera*), other types of managed bees may be used for pollination services. Examples include bumblebees (*Bombus spp*), mason bees (*Osmia spp*), and leafcutter bees (*Megachile spp*). Sometimes growers manage their own bees and do not rely on contracted services. However, in some cases the use of these bees could still result in a contract scenario. This analysis does not account for such a situation, and only focuses on scenarios where growers utilize commercially available honeybees that are placed on-farm under a contract for pollination services.

PESTICIDE USAGE DATA

Market Research Data (MRD) was used for assessing pesticide usage including target pest identification and subsequent identification of likely alternatives for most crops in this document. However, for blueberries, cranberries, and alfalfa grown for seed, MRD are not available and BEAD relied upon usage data from the United States Department of Agriculture's National Agricultural Statistics Service (USDA-NASS) and/or on published state extension recommendations.

When utilizing MRD, BEAD typically relies upon a five-year average when assessing and reporting pesticide usage. Because various aspects of the analyses underpinning this memorandum were conducted at different times, the five-year windows cited in some tables, figures, and calculated averages in this memorandum may not exactly correspond with one another, due to periodic updates in data availability. BEAD will not typically re-calculate such averages or re-analyze large data summaries across the board, since data will still have 60-80% temporal overlap (i.e., 3 or 4 out of 5 years will be the same) in most cases.

PILOT CROP SELECTION—REPRESENTATION OF RELEVANT BLOOMING CROPS UTILIZING COMMERCIAL POLLINATION SERVICES

BEAD selected pilot crops to represent the diversity of major crops that utilize pollination services. Almonds are highly dependent on commercial pollination and constitute the largest users of contract honeybee services in the U.S. Apples were selected as a surrogate for pome and stone fruits. While the apple analysis is split regionally, it is assumed that given the similar pest complexes, timing and duration of bloom, and similar pest control approaches, that apples would be a viable surrogate for representing the most likely impacts to production of all deciduous tree fruits. Strawberries, caneberries, blueberries, and cranberries were assessed to evaluate the diversity of small fruit production that also heavily relies on commercial bees. Cucurbits are represented by pilot analyses of cucumbers, cantaloupes (as a surrogate for melons), pumpkins, and squash, and various regional scenarios were analyzed to capture the diversity of the major cucurbit production states in the U.S. Sunflowers were analyzed because this crop was identified as the second leading source of commercial pollination fees in the U.S. (although many sunflower growers do not use bees). Finally, seed alfalfa was chosen as a surrogate for seed production, which includes various blooming forage and feed crops.

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PILOT CROP OVERVIEWS

ALMONDS

OVERVIEW

California is the main almond-producing state in the U.S. with approximately 936,000 acres of almonds (both bearing and non-bearing) grown in 2012 (USDA-NASS, 2012). The majority of California almonds are grown in the San Joaquin valley where 650,000 acres are contained in five counties: Fresno, Kern, Madera, Merced, and Stanislaus. Depending on the variety, almond trees bloom from late February through early to mid-March. For the purposes of this analysis, the bloom time in almonds is defined as the popcorn stage through petal fall. (Note: These crop stages are used in the survey of growers by the market research firm).

California's Code of Regulations, Title 3, currently contains some provisions for pollinator protection that include notifying beekeepers when toxic pesticides will be applied and restricts applications in citrus areas during bloom of certain pesticides that are toxic to bees (Cal DPR, 2104). However, only the notifications, not the bloom-time restrictions, apply to almonds. The Almond Board of California recently released Honey Bee Best Management Practices (BMPs) for almonds which focus on the importance of communication between almond growers and beekeepers, how to apply pesticides during bloom (including insecticides and fungicides) in ways that minimize impacts to honey bees, and ways to reduce agricultural sprays through use of Integrated Pest Management (IPM) strategies. The BMPs recommend avoiding sprays of insecticides during bloom, especially those with labels that indicate high toxicity to bees or extended residual toxicity.
Despite the existence of these BMPs, a policy prohibiting application of chemicals acutely and moderately toxic to bees during bloom would be a new requirement for California almond growers.

USAGE OF MHATS ON ALMONDS

When taken in total on a seasonal basis, MHAT insecticides constitute approximately half of all insecticide treated acres for almonds (MRD, 2008-2012). Table 1 summarizes the current usage of insecticides and miticides that are MHAT to bees during bloom time, based upon MRD (2008-2012). The top two MHAT insecticides/miticides applied during bloom in terms of average annual total acres treated (2008-2012) are abamectin and esfenvalerate with 26,000 and 9,000 average annual acres treated, respectively. This is a small proportion of total almond acreage, which averaged over 900,000 acres grown from 2008-2012

The proportion of total acres treated during bloom (defined as popcorn stage through petal fall) for each of these chemicals is shown in Table 1. These chemicals represent the leading MHAT insecticides used during bloom time on almonds. These numbers include all treatments across all pests. Abamectin, a miticide which is highly acutely toxic to bees, is frequently used on almonds but the vast majority of these applications occur after bloom, not during bloom. Only about three percent of the total acres treated with abamectin are treated during bloom. Esfenvalerate, which is effective in controlling aphids and scale, is used to treat only about 9,000 acres annually during bloom, or 3% of total acres treated with this chemical annually. Though a number of MHAT insecticides are used during bloom, proprietary usage data indicate that the overall percent crop treated for these chemicals is very low. Abamectin, for example, which is the leading miticide applied to almonds during bloom, is applied to less than 3% of almonds annually;

even fewer acres are treated with esfenvalerate (MRD, 2008-2012). Therefore, in estimating a percentage of the total almond acreage treated during bloom with one or more MHAT chemicals, BEAD concludes that it would be a minimum of 3%, based on the usage of abamectin, which is the leading insecticide/miticide used on almonds during bloom, and a maximum of 8%, which is derived by adding all the almond acreage treated with any MHAT chemical during bloom. The low percentages further indicate that these chemicals are not likely to have a high importance for pest management during bloom (Table 1). The majority of usage of these chemicals in almonds occurs during stages outside of bloom stages.

Table 1: Almond Acres Treated During Bloom Stages with MHAT Insecticides/Miticides, 2008-2012

Active Ingredient	Total Acres Treated, Bloom Stages [1]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
ABAMECTIN	26,000	3%
ESFENVALERATE	9,000	3%

[1] For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include popcorn, full bloom, and petal fall.
[2] For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages. Additional MHAT insecticides/miticides applied to almonds during bloom stages accounts for about 2 percent of acres treated.
Source: Market Research Data, 2008-2012. Numbers may not add due to rounding.

MRD indicate that lepidoptera (including twig borers, navel orange worm, etc.), mites, aphids, and scale are the most important pests of almonds (in terms of total acres treated) during bloom (Table 2). The first column indicates the relative importance of bloom stage applications for controlling each type of pest. Overall, 23% of total acres treated for lepidoptera are applications made during bloom time. Approximately 4% of the acres treated targeting mites occur during bloom, and about 23% of acres treated targeting aphids and scale occur during bloom. The second column indicates the relative importance of this pest during bloom time relative to other pests. The vast majority (70%) of treatments applied to almonds during the bloom period are targeting Lepidopteran pests, though most of these applications are non-bee toxic chemicals. Mites, aphids, and scale are relatively less important pests during bloom stages with 17% and 3% of acres of applications targeting these pests, respectively.

Table 2: Percentages of Applications (All Active Ingredients) Targeting a Particular Pest, Bloom Stages Only, 2008-2012

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages[2]	Percent of Total Bloom Time Treated Acres by Target Pest[3]
Lepidoptera [1]	23%	70%
Mites	4%	17%
Aphids, Scale	23%	3%

[1] Includes Twig Borer, Peach Tree Borer, Navel Orange Worm, Oriental Fruit Moth, and Codling Moth.
Source: Market Research Data, 2008-2012. Numbers may not add due to rounding.
[2]Of all pesticide applications that were made to almonds throughout the year—including before, during, and after the bloom stage—this number represents the percentage of treated acres that were made during the bloom stage for each pest listed in the Pest column.

[3]*This number represents the percentage of bloom time pesticide applications on almonds across all active ingredients that target each pest listed in the Pest column.*

OPTION 1: MHAT INSECTICIDE USAGE IS PROHIBITED DURING BLOOM

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

As was discussed previously, the percentage of overall treatments with MHAT insecticides that occur during bloom is small. The BMPs recently released by the CA Almond Board may cause those percentages to fall even lower. Much of the pest control conducted on almonds at bloom time targets Lepidopteran pests, and the leading MHAT insecticides abamectin and esfenvalerate are not the leading choices for those pests. Currently, almond growers are already likely to use diflubenzuron or chlorantraniliprole to control several Lepdiopteran pests, including peach twig borer (PTB), navel orange worm (NOW), and oriental fruit moth (OFM). Because neither of these chemicals are considered MHAT to bees, the use of diflubenzuron or chlorantraniliprole would not change under the proposed mitigation option 1.

For those growers that need to control mites, aphids, and scale during bloom stages, there will be expected impacts from the increased cost of switching from abamectin and esfenvalerate, respectively, to non-MHAT insecticide treatments targeting. The costs of these chemical control options compared to the likely leading alternatives adopted under the proposed mitigation are presented in Table 3. Abamectin is used to control mites under the current option at a cost of $22 per acre, with some applications occurring during bloom stages. Hexythiazox is likely be used to control mites under the proposed mitigation, as it is the next most commonly used conventional miticide in almonds (MRD, 2008-2012). Hexythiazox would approximately double the per acre cost of mite control compared to abamectin (MRD, 2008-2012). Under the current control scenario, esfenvalerate is most widely used to control aphids and scale. Under the proposed mitigation option 1, spirotetramat is a likely replacement for esfenvalerate. Switching to spirotetramat may increase costs of production for almond growers by $57 per acre for growers targeting aphids and/or scale during bloom periods (MRD, 2008-2012).

Table 3: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Almonds Option 1.

Target Pest(s)	**Current Chemical Controls**		**Expected Chemical Controls Under Mitigation**	
	Active Ingredient	**Cost ($/A)**	**Active Ingredient**	**Cost ($/A)**
Mites	Abamectin	**$22**	Hexythiazox	**$44**
Aphids, Scale	Esfenvalerate	**$7**	Spirotetramat	**$64**
	Total Chemical Cost, Current Scenario	**$29**	*Total Chemical Cost, Mitigation Scenario*	**$108**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($79)**

Source: Market Research Data, 2008-2012. Prices of active ingredients represent 2008-2012 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. Only foliar products are used to control the pests listed in Table 2 (MRD, 2008-2012). Hence, this is not a viable option for almond growers.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios and in situations where control is not possible without abamectin and/or esfenvalerate, significant yield losses would be expected if no applications were made of these products.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. For the pests being targeted in these scenarios, some variation in timing to avoid applications during bloom may be possible, particularly for mites (after bloom) and aphids/scale (pre-bloom/delayed dormant). For mites, because of the potential for large and sudden outbreaks, exceedance of threshold levels could also sometimes necessitate miticide applications during bloom. For the aphids and scale, in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses to 3 to 8 percent of almond acres would be expected if applications were made outside of bloom time.

OPTION 2: RISK-BASED LIMITATIONS ON PESTICIDE USAGE

The cost of current pesticides vs. the likely alternatives is presented in Table 4. The estimated impact from substitution costs under mitigation option 2 would be less, due to the availability of acetamiprid to replace esfenvalerate for control of scale and aphid pests. Acetampirid is not currently a leading insecticide choice for almonds, and it is a chemical that would be classified as MHAT under mitigation option 1. However, given its known efficacy against scale and aphid pests, it is likely to be a leading alternative choice under scenario 2, since the likely application rates are not considered acutely toxic to bees. Switching to acetamiprid may increase costs of production for almond growers by $31 per acre for growers targeting aphids and/or scale during bloom periods, which is less of an increase than was projected for spirotetramat under option 1. Substitution costs for miticides would remain the same as in option 1.

Table 4: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Almonds Option 2

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**Cost ($/A)**	**Active Ingredient**	**Cost ($/A)**
Mites	Abamectin	**$22**	Hexythiazox	**$44**
Aphids, Scale	Esfenvalerate	**$7**	Acetamiprid	**$38**
	Total Chemical Cost, Current Scenario	**$29**	*Total Chemical Cost, Mitigation Scenario*	**$82**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($53)**

Source: Market Research Data. Prices of active ingredients represent 2008-2012 5-year average.

ALMOND SUMMARY

While mites might be a leading driver of abamectin usage during bloom, their control during bloom is typically not as critical during this specific time-limited crop stage. Control of Lepidopteran pests accounts for the majority of insecticide treatments applied during bloom. However, due to the availability of diflubenzuron, methoxyfenozide, and chlorantraniliprole (which are not MHAT to bees) for the control of Lepidoptera, the impact of MHAT restrictions is low overall because minimal substitution would be necessary for control of those pests. This leaves substitution for the control of mites, aphids, and scale as the main drivers of the projected impact. Growers only needing to target mites via an alternative to abamectin during bloom would be projected to see about a $22 per acre impact, while those needing to target aphids/scale would see an additional $57 per acre impact under option 1 and $31 impact under option 2.

Given current usage patterns, it is likely that these projected impacts would affect less than 8% of almond acreage. Under either mitigation option, a $22/acre impact for mite control on 26,000 affected acres gives a total impact to almond growers of $572,000. Another $31-$57/acre impact for aphid and scale control on 9,000 acres (some of which may be the same acres as noted previously, adds another $279,000 - $513,000 for mitigation options 2 and 1, respectively, for a total impact of $1.1 million under option 1 and $850,000 under option 2.

POME AND STONE FRUITS

OVERVIEW

For analysis of pome and stone fruits, apples were used as the proxy crop, due to the general similarities of target pest groups, and the distinct production differences between East Coast (i.e., east of the Mississippi) and West Coast (i.e., California, Washington and Oregon) that generally hold true for most crops in these groups. While some variability exists between crops and bloom times, BEAD projects that apples provide a reasonable proxy for production costs and likely substitution choices for all pome fruits, and most stone fruits, particularly peaches, nectarines, plums, and cherries.

APPLES—EAST COAST

OVERVIEW

The primary apple producing states on the east coast are New York (49,900 acres grown), Michigan (45,300 acres grown), Pennsylvania (23,800 acres grown), Virginia (13,600 acres grown), North Carolina (7,000 acres grown), Ohio (6,000 acres grown), and West Virginia (4,800 acres grown) (MRD, 2008-2012 average). This accounts for 44% of total apple acreage grown in the United States. Although bloom time can vary depending on weather, variety, and location, it typically occurs in March, April, or May. For apples, this period is known as first pink through petal fall (bloom stage categories used in MRD). BEAD is uncertain regarding the time period that managed pollinators are brought into pollinate east coast apples; in many cases managed pollinators are brought in prior to bloom time, are left after bloom time, or are only present for part of bloom time. For this analysis, it is assumed that bees are present from first pink to petal fall.

To date, no east coast apple states have state pollinator protection plans in place. Therefore, no further analysis of the potential impacts from state pollinator plans was conducted for east coast apples.

USAGE OF MHATS ON EAST COAST APPLES

When taken in total on a seasonal basis, MHAT insecticides constitute approximately 70% of all insecticide treated acres for east coast apples (MRD, 2008-2012). Table 5 presents information on the proportion of total acres treated during bloom (first pink through petal fall) for each of these chemicals. These chemicals represent the leading MHAT insecticides used during bloom time on east coast apples (MRD, 2008-2012). These numbers include all treatments across all pests. Abamectin is frequently used as a miticide and is applied to approximately 20,000 acres during bloom, or 62% of total acres treated annually with this chemical is during bloom (because abamectin is systemic and efficacy is dependent on application to freshly emerged foliage, most usage is early in the growing season, which includes the period of bloom) (PSU, 2014). Lepidopteran pests (primarily overwintering leafrollers and ovipositing fruit feeders such as codling moth and oriental fruit moth), scale, and early-season aphids are often targeted by acetamiprid or chlorpyrifos (MRD, 2008-2014), which both provide broad spectrum control. Acetamiprid is used to treat approximately 50,000 acres during bloom—or 43% of total acres treated annually with acetamiprid is during bloom —while 57% of total acres treated with chlorpyrifos occur during bloom, which equates to 62,000 acres.

From 2008 to 2012, approximately 150,000 total apple acres were grown on average in the states listed above. Of the top MHAT chemicals used during bloom, as presented in Table 5, chlorpyrifos represented the highest percent crop treated for an individual chemical based on the highest total acres treated (i.e., the leading insecticide used during bloom periods) and was used on 41% of apple acres during bloom (MRD, 2008-2012: USDA NASS, 2008-2012). Therefore, BEAD concludes that the total acreage treated during bloom with any MHAT chemical is no less than 41 and could be up to 100% under an upper-bound usage scenario, when all acreage treated with MHAT chemicals during bloom are added.

Table 5: East Coast Apples, Proportion of Total Acres Treated during Bloom Stages with Insecticides/Miticides Moderately or Highly Acutely Toxic to Bees, 2008-2012

Active Ingredient	Total Acres Treated, Bloom Stages [1]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
ABAMECTIN	20,800	62%
ACETAMIPRID	50,900	43%
CHLORPYRIFOS	61,700	57%
CARBARYL [3]	7,900	14%

[1]For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include first pink through petal fall.
[2] For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages
[3] Carbaryl, which is used as a fruit thinner is discussed below in the section entitled "Additional Considerations/Uncertainties."
Source: MRD, 2008-2012. Numbers may not add due to rounding.

Table 6 presents an overview of the percentage of applications targeting leading pests during bloom time. The first column indicates the importance of bloom stage applications for controlling each type of pest. MRD indicate that aphids and scale, lepidoptera, mites, and plum curculio are the most important pests for east coast apples (in terms of total acres treated) that are present during bloom time. Approximately 41% of acres treated for aphids and scale are treated during bloom. It should be noted that 'aphids' encompasses multiple species. Within that group, the rosy apple aphid is a primary target pest during the early part of the growing season due to its limited presence on apple tree hosts and unique life cycle, during which it can cause both indirect and direct damage. Fifteen percent of the acres treated for Lepidoptera are treated during bloom (inclusive of both overwintering leafrollers and adult moths of fruit feeding species that are actively laying eggs during or immediately after the typical apple bloom period), 29% of the acres treated for mites are treated during bloom, and 43% of acres treated for plum curculio are treated during bloom. The second column indicates the importance of this pest during bloom time relative to other pests. When considering all insecticide applications made during bloom, the vast majority (67-70%) of applications are targeting aphids, scale, or Lepidoptera, and many applications are tank mixed with ingredients that target both pests simultaneously.

Table 6: East Coast Apples, Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, 2008-2012

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages[2]	Percent of Total Bloom Time Treated Acres by Target Pest[3]
Aphids, Scale	41%	70%
Lepidoptera [1]	15%	67%
Mites	29%	17%
Plum Curculio	43%	26%

[1] Lepidoptera includes both leafrollers and fruit feeders.
[2] Of all pesticide applications that were made to apples throughout the year—including before, during, and after the bloom stage—this number represents the percentage of treated acres that were made during the bloom stage for each pest listed in the Pest column.
[3] This number represents the percentage of bloom time pesticide applications on apples across all active ingredients that target each pest listed in the Pest column.
Source: Market Research Data, 2008-2012. Numbers may not add due to rounding.

ADDITIONAL CONSIDERATIONS/UNCERTAINTIES

In addition to pest control, it is notable that carbaryl—which is also considered highly acutely toxic to bees—is used extensively in apples for fruit thinning. While most fruit thinning applications are typically made after petal-fall, some thinning applications of carbaryl can begin before all flowers in an orchard have fallen and/or before all bees are removed from a given site. Such applications can be made in response to a number of factors that necessitate thinning before bloom is entirely complete. For example, extended bloom periods can occur in apples due to cold weather, whereby early pollinated flowers have already developed into fruit of adequate size for thinning while later emerging blossoms still remain on the tree. Also, because apples of different varieties are often inter-planted, sometimes early setting varieties may be ready to thin while other varieties in the same orchard are still in full or partial bloom. In the absence of carbaryl, growers would have to substitute other plant growth regulators (PGR) in some cases and/or potentially incur additional expenses for hand-thinning of fruit. However, this potential impact is difficult to estimate, given that many PGRs are already used in combination with carbaryl. Furthermore, the thinning efficacy of carbaryl and other alternative PGR materials (and various combinations thereof) is highly variable and subject to many other site-specific variables, including factors such as cultivar, fruit size, weather, previous crop-load, application rates, etc. (PSU, 2014). The complexity of chemical thinning applications makes it difficult to accurately project meaningful impact estimates within the scope of this analysis. BEAD therefore identifies the loss of carbaryl for fruit thinning as a potentially significant uncertainty.

Of further note, the recently invasive Brown Marmorated Stink Bug (BMSB) has emerged as a particularly problematic pest for apple growers in the eastern United States. While BMSB is not typically targeted with sprays at bloom time, inordinate population pressure can necessitate control in some situations. Most synthetic pyrethroids and some neonicotinoid, organophosphate, and carbamate insecticides are effective against this pest (Rice et al., 2014). At this time, all the known, viable chemical control options for BMSB are MHAT to bees. Again, due to the sporadic nature of these pest outbreaks, the factors affecting pesticide efficacy, and the other variables that affect BMSB population dynamics and control, BEAD simply mentions this as another potentially significant uncertainty.

OPTION 1: MHAT INSECTICIDE USAGE IS PROHIBITED DURING BLOOM

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

If use of chemicals like abamectin, acetamiprid, and chlorpyrifos were prohibited during bloom, growers would have to use a combination of products that are not MHAT to bees to provide the a similar level of broad spectrum pest control. A likely tank-mix of pesticides that are not MHAT to bees would be: clofentezine, hexythiazox, or etoxazole (i.e., a non-toxic miticide) + methoxyfenozide (fruit feeding leafrollers) + spirotetramat (aphids and scale cleanup). Control of overwintering leafroller larvae, currently controlled by applications of either chlorpyrifos or esfenvalerate would likely shift to an earlier pre-pink timing. Table 7 provides an overview of expected impacts to growers on a per acre basis. Note that for plum curculio, acetamiprid, esfenvalerate, and chlorpyrifos would provide efficacy against plum curculio. Under the proposed mitigation scenario, there are no AIs that provide control that are not MHAT to bees. Not controlling for plum curculio during the late bloom to early petal-fall period could result in an upper-bound 10% loss in yield/quality. This is a qualitative estimate that could vary significantly.

While high plum curculio population pressure during late bloom stages can lead to both apple drop and some fruit damage, quality loss damage is more likely to occur after fruit set. Therefore, the delayed control option could be adequate in many instances, even in the absence of bloom time applications. However, in cases where conditions arise to preclude adequate plum curculio control due to bloom time application restrictions, considerable yield and quality losses should be expected. Taking this variability into account, BEAD's estimated impacts range from $65 to $696/acre, with up to $600 of this impact attributable to the uncertainty associated with potential losses from plum curculio damage. Additional costs could also be incurred by growers that are facing stink bug outbreaks during bloom or are using carbaryl for fruit thinning.

Table 7: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, East Coast Apples Option 1

Target Pest(s)	**Current Chemical Controls**		**Expected Chemical Controls Under Mitigation**	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Mites	Abamectin	**$22**	Clofentezine, hexythiazox, or etoxazole	**$37 - $46**
Aphids, scale, and Lepidoptera	Acetamiprid or Esfenvalerate or Chlorpyrifos	**$5-$27**	Spirotetramat (aphid, scale) and methoxyfenozide (lepidoptera; egg and larval stages)	**$77**
	Total Chemical Cost, Current Scenario	**$27-$49**	*Total Chemical Cost, Mitigation Scenario*	**$114-$123**
			Potential Additional Yield and Quality Losses from Plum Curculio *	**$400-$600**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($65-$696)**

*Numbers may not add due to rounding. * Yield loss reflects a 10% loss from plum curculio. Yield loss estimated using typical yields and prices received for MI and PA apples ($0.20/lb, 20,000-30,000 lb/A,* *2011-2012 3-year average). Sources: USDA NASS (2011-2013); Market Research Data, 2008-2012. Prices of active ingredients represent 2008-2012 5-year average.*

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. No non-foliar application options exist to replace the products that are being limited for the pest spectrum that is being targeted.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICALS(S): For the pests being targeted in these scenarios, and in situations where control is not possible without applications of abamectin, acetamiprid, esfenvalerate, or chorpyrifos, significant yield loss would be expected if no applications were made of these products.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. For the pests being targeted in these scenarios, some variation in timing to avoid applications during bloom may be possible, particularly for plum curculio (after bloom) and aphids/scale (pre-bloom/delayed dormant). Alternative mite control tactics may also be possible, but because of the potential for large and sudden outbreaks, exceedance of treatment threshold levels could also sometimes necessitate miticide applications during bloom. While a moderate mite outbreak might still be effectively controlled with a delayed application, high population pressure that leads to significant leaf bronzing during bloom could significantly impact tree health and fruit development later in the season (PSU, 2014). For the other listed pests, and in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time due to control failures.

OPTION 2: RISK-BASED LIMITATIONS ON PESTICIDE USAGE

Table 8 compares the current chemical controls used by east coast apple growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal. The estimated impact from substitution costs would be less than in option 1, due to the availability of acetamiprid for control of scale, aphid, and Lepidopteran pests present during the bloom period. Substitution costs for miticides would remain the same as in option 1. Switching to acetamiprid from esfenvalerate or chlorpyrifos may increase costs of production for apple growers by up to $22 per acre for growers targeting aphids and/or scale during bloom periods, which is less of an increase than was projected for spirotetramat under option 1. However, using acetamiprid would eliminate the risk of losses from plum curculio, since this chemical is rated as an excellent control for this pest (PSU, 2014).

Table 8: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, East Coast Apples Option 2

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	$/A	Active Ingredient	$/A
Mites	Abamectin	$22	Clofentezine, hexythiazox, or etoxazole	$37 - $46
Aphids, scale, and Lepidoptera	Acetamiprid or Esfenvalerate or Chlorpyrifos	$5-$27	Acetamiprid (aphid, scale, lepidoptera; egg and larval stages)	$27

	Total Chemical Cost, Current Scenario	**$27-$49**	*Total Chemical Cost, Mitigation Scenario*	**$64-$73**
			*Potential Additional Yield and Quality Losses from Plum Curculio **	**$0**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($15-46)**

*Numbers may not add due to rounding. * Yield loss from plum curculio is eliminated due to availability of acetamiprid). Sources: USDA NASS (2011-2013); Market Research Data. Prices of active ingredients represent 2008-2012 5-year average.*

UNCERTAINTIES: GROWER CHANGES POLLINATOR PRACTICES.

In the case of east coast apples, ceasing to use contracted pollinators may be a viable response to the limitation of MHAT materials during bloom. Native pollinators have been found in some cases to be sufficient pollinators for apples. And due to the unique geography and topography of eastern apple growing regions (i.e., interdigitation of woodland and riparian areas with apple orchards), high population levels of native pollinator species have been reported (Park et al., 2012). However, restriction of bloom time pesticide usage is likely to also benefit native bees.

EAST COAST APPLE SUMMARY

BEAD's analysis indicates that east coast apple production relies upon broad-spectrum insect control options during periods near bloom. While alternatives are available for control of mites, aphids, scale, and fruit feeding lepidoptera (at higher costs), there were no viable alternatives available for control of plum curculio, under option 1. Plum curculio is a pest that causes direct feeding damage during the early season. In the absence of available tools, some growers would be expected to experience significant economic losses due to damage from plum curculio in their apple orchards in situations where such populations cannot be controlled via delayed insecticide applications. BEAD does not have adequate information to determine the percentage of growers that would likely see losses from plum curculio under option 1, but for those growers that do experience losses, the impact would be very large. Chlorpyrifos is currently used on about 41% of eastern apples during bloom and is the most widely used insecticide during bloom periods to target these pests. Given this observed usage, BEAD estimates that at a minimum 41% of eastern apple acreage would be impacted by the proposed mitigations, and up to 100% of acreage could be affected under an upper-bound usage scenario, when considering the potential additive usage (i.e., acreage treated) of all MHAT chemicals currently used during the bloom periods in east coast apples.

Under option 2, the likely substitution costs for aphids, scale, and Lepidopteran pests is reduced due to the availability of acetamiprid, which is effective against all of these pest groups. Furthermore, the availability of acetamiprid would likely eliminate the risk of large yield losses due to damage from plum curculio, since acetamiprid is very effective against this pest. Substitution costs for control of mites would remain the same as option 1.

Given observed usage patterns, it is likely that these projected impacts would affect a substantial number of growers under either scenario. For mite control, under either scenario, a $15-24 per acre impact on 21,000 affected acres gives a total impact of $315,000 to $504,000 to east coast apple growers. However, a much larger impact comes from the remaining $641 per acre projected to control other pests and also includes the potential yield losses from plum curculio, which could affect all 151,000 acres of apples grown in the eastern U.S., totaling $97 million under mitigation option 1. Under mitigation option 2, this impact is greatly reduced to an additional $31 per acre. Assuming that all 151,000 apple acres are still affected, this projects to a reduced impact of $4.7 million.

APPLES—WEST COAST

OVERVIEW

The primary apple producing states on the west coast are Washington (163,700 acres grown), California (19,900 acres grown), and Oregon (5,500 acres grown) (2008-2012 average). This accounts for 56% of apple acres grown in the United States—with 48% of U.S. apples grown in Washington State alone (NASS 2008-2013). Although bloom time can vary depending on weather, variety, and location, it typically occurs in mid-April to mid-May. For apples, this period is referred to as first pink through petal fall (MRD, 2008-2012). BEAD is uncertain regarding the time period that managed pollinators are brought into pollinate west coast apples; in many cases managed pollinators are brought in prior to bloom time, are left after bloom time, or are only present for part of bloom time. For this analysis, it is assumed that bees are present from first pink to petal fall.

To date, California is the only state that has a state pollinator protection plans in place. However, limitations on pesticide applications are currently for avocado and citrus only and other restrictions and/or Best Management Practices (BMPs) have not been established for other crops at the time this analysis was conducted. Regulations germane to bees are summarized by Cal DPR (2014).

USAGE OF MHATS ON WEST COAST APPLES

When taken in total on a seasonal basis, MHAT insecticides constitute approximately half of all insecticide treated acres for west coast apples (MRD, 2008-2012). MRD indicates that some applications of pesticides that are MHAT to bees are being made during bloom time, as presented in Table 9. Top insecticide usage on west coast apples is for the treatment of aphids and Lepidoptera (including leafrollers and fruit feeders). Currently, acetamiprid or imidacloprid are the leading chemicals used to control aphids on west coast apples. Acetamiprid is used to treat approximately 24,000 acres during bloom (27% of total acetamiprid treated acres) while imidacloprid is used on 16,500 acres during bloom, (17% of total seasonal imidacloprid treated acres). Methoxyfenozide is a non-MHAT chemical that is already a leading insecticide used against Lepidopteran pests. In addition, fruit thinning is often done using carbaryl. Acetamiprid, imidacloprid, and carbaryl are considered acutely toxic to bees and would not be available to west coast apple growers under the proposed option 1.

From 2008 to 2012, the average annual total crop area grown for west coast apples in California, Washington, and Oregon was approximately 190,000 acres. Of the top three MHAT chemicals used during bloom, as presented in Table 8, carbaryl bloom time applications represent the highest percent crop treated for an individual chemical and is used on about of 38% of apple acres (MRD, 2008-2012; USDA NASS, 2008-2012). Therefore, in estimating a percentage of the total acreage treated during bloom with an MHAT chemical, BEAD estimates that it would be no less than 38% for west coast apples, with an upper-bound estimate of 52% derived from additive usage (i.e., all the combined acres treated) of all MHAT chemicals currently used during bloom periods.

Table 9: West Coast Apples Proportion of Total Acres Treated during Bloom Stages with Insecticides/Miticides that are Considered Moderately or Highly Acutely Toxic to Bees, 2008-2012

Active Ingredient	Total Acres Treated, Bloom Stages [1]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
ACETAMIPRID	24,100	27%
IMIDACLOPRID	16,500	17%
CARBARYL [3]	72,800	67%

[1]*For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include first pink through petal fall.*
[2] *For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages*
[3] *Carbaryl can be used for fruit thinning, but usage data indicate that it is also used for pest control during bloom periods in Western states.*
Source: MRD, 2008-2012. Numbers may not add due to rounding.

Table 10 presents an overview of the percent crop treated for species of aphids and lepidopteran that are typically controlled for during bloom time in west coast apples. The first column indicates the importance of bloom stage applications for controlling each type of pest. About 24% of treated acres targeting aphids and scale are treated during bloom. For Lepidoptera, about 13% of all acreage treated targeting these pests is applied during bloom. The second column indicates the importance of this pest during bloom time relative to other pests. Over 40% of total acres treated during bloom time are treated for Lepidoptera, while 26% are treated for aphids. Unlike the eastern scenario, plum curculio is not currently present as a pest in west coast apple production.

Table 10: Percentages of Applications Targeting a Particular Pest, Bloom Time Only, 2008-2012

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Time[2]	Percent of Total Bloom Time Treated Acres by Target Pest[3]
Aphids, Scale	24%	26%
Lepidoptera[1]	13%	40%

[1] *Lepidoptera includes both leafrollers and fruit feeders.*
[2]*Of all pesticide applications that were made to apples throughout the year—including before, during, and after the bloom stage—this number represents the percentage of treated acres that were made during the bloom stage for each pest listed in the Pest column.*
[3]*This number represents the percentage of bloom time pesticide applications on apples across all active ingredients that target each pest listed in the Pest column.*
Source: Market Research Data, 2008-2012. Numbers may not add due to rounding.

Additional Considerations/Uncertainties

Carbaryl is also used extensively for thinning in the Western U.S. Please refer to the discussion of carbaryl in the previous section under east coast apples entitled "Additional Considerations/Uncertainties."

OPTION 1: MHAT INSECTICIDE USAGE IS PROHIBITED DURING BLOOM

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES.

As shown in Table 11, under proposed label requirements, growers could use spirotetramat in place of acetamiprid or imidacloprid for the control of aphids and scale but this substitution would result in additional costs of $7 to $31 per acre, depending upon the original MHAT insecticide choice. Since acetamiprid and methoxyfenozide are equivalent in price, a grower using acetamiprid to control for both aphids and lepidoptera, would see an increase in cost from having to apply both spirotetramat and methoxyfenozide, based upon the substitution costs of spirotetramat. But growers seeking to control only lepidoptera would see a minimal impact by substituting methoxyfenozide, since the per acre cost is the same as acetamiprid. Therefore, the total net impacts from having to switch to non-MHAT chemicals for the control of aphids and Lepidoptera are estimated to fall between $7 and $31/acre.

Table 11: Comparison of Current Control Measures Possible Control Measures that would be Allowed under the Mitigation Option 1, West Coast Apples.

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Aphids	Acetamiprid or Imidacloprid or Chlorpyrifos	**$8-$32**	Spirotetramat	**$39**
Lepidoptera	Acetamiprid or Carbaryl or Methoxyfenozide	**$27**	Methoxyfenozide	**$27**
	Total Chemical Cost, Current Scenario	**$35-$59**	*Total Chemical Cost, Mitigation Scenario*	**$66**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($7-$31)**

Numbers may not add due to rounding. Source: Market Research Data. Prices of active ingredients represent 2008-2012 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. No non-foliar application options exist to replace the products that are being limited for the pest spectrum that is being targeted.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios, and in situations where control is not possible without applications of MHAT insecticides, significant yield loss would be expected if no applications were made of these products.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. For the pests being targeted in these scenarios, some variation in timing to avoid applications during bloom may be possible for the control of aphids (pre-bloom/delayed dormant) or some leafrollers (petal fall). However, situations could occur where adequate control is not possible without bloom-time insecticide applications. Failing to make such applications could result in significant yield losses.

OPTION 2: RISK-BASED LIMITATIONS ON PESTICIDE USAGE

Table 12 compares the current chemical controls used by west coast apples growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal. The estimated impact from substitution costs would be less than option 1, due to the availability of acetamiprid for control of aphid, and Lepidopteran pests present during the bloom period. Switching to acetamiprid from imidacloprid or chlorpyrifos may increase costs of production for apple growers by up to $24 per acre for growers targeting aphids during bloom periods.

Table 12: Comparison of Current Control Measures for Growers to Possible Control Measures that would be Allowed under Mitigation Option 2, West Coast Apples.

Target Pest(s)	**Current Chemical Controls**		**Expected Chemical Controls Under Mitigation**	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Aphids	Acetamiprid or Imidacloprid or Chlorpyrifos	**$8-$32**	Acetamiprid	**$32**
Lepidoptera	Acetamiprid or Carbaryl or Methoxyfenozide	**$27**	Methoxyfenozide	**$27**
	Total Chemical Cost, Current Scenario	**$35-$59**	*Total Chemical Cost, Mitigation Scenario*	**$59**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($0-$24)**

Numbers may not add due to rounding. Source: Market Research Data. Prices of active ingredients represent 2008-2012 5-year average.

UNCERTAINTY: GROWER CHANGES POLLINATOR PRACTICES.

Unlike east coast apples, west coast apples are grown in areas of large mono-culture and heavily managed landscapes. Thus, growers in the west are more dependent than growers in the east on managed pollinators for crop pollination as native pollinators that are good apple pollinators are less abundant near orchards on the west coast. Ceasing to use contracted pollinators could result in significant yield and quality losses.

West Coast Apple Summary

BEAD's analysis indicates that while west coast apple production does rely upon broad-spectrum insect control options during periods near bloom, the required spectrum of control is not as large or varied as the eastern scenario. Non-MHAT alternatives are available for control of aphids, scale, and fruit feeding lepidoptera (albeit at higher costs). But unlike the eastern scenario, there are no pests that cannot be controlled by non-MHAT chemical tools. BEAD projects that the cost of substitution will vary somewhat depending upon what pests are present during this bloom time and which MHAT chemicals a grower was using initially. While mite populations can vary significantly, control of pests such as scale, rosy apple aphids, and fruit feeding lepidoptera is often a yearly necessity. Growers needing to target one or more of these pests would be projected to see about a $7-31 per acre impact under option 1. For growers already using methoxyfenozide to target lepidopteran pests, no substitution would be necessary because methoxyfenozide is non-MHAT to bees. Under option 2, projected substitution costs are reduced further to $0-24 per acre.

Carbaryl is the most widely used insecticide during bloom periods to target these pests and is used on about 38% of western apple acres during periods near bloom. Therefore, at a minimum it is expected that no less than 38% of western apple acreage would be impacted by the proposed mitigation, and up to 52% of acreage could be affected under an upper-bound usage scenario, when considering potential additive usage of all MHAT chemicals currently used during the bloom periods in west coast apples.

Given observed usage patterns, and assuming the upper-bound estimate of 52% of affected apple acreage (approximately 99,000 acres) the impact of mitigation option 1 ($7-31 per acre) would total between $693,000 and $3 million. Under mitigation option 2 ($0-24), this impact is reduced to a total between $0 and $2.4 million.

Berries

For BEAD's analysis of berries, a number of representative crops were chosen for this analysis, based upon their known reliance on pollination services and public comments that indicated impacts of bloom-time restrictions would be significant. Representative crop scenarios include strawberries (CA and FL), caneberries, blueberries, and cranberries. It should be noted that MRD for pesticide usage by pest and crop stage are not available for blueberries and cranberries, and therefore, these scenarios are presented qualitatively.

Strawberries

Overview

The annual U.S. acres planted of strawberries are 59,500 acres (2009-2013 average, USDA NASS). With an average annual planted area of approximately 39,400 acres, California is the major producer of strawberries. The next major producer is Florida, with 9,800 acres planted. These two states account for about 83% of the U.S. strawberry acres planted. For the purposes of this analysis, the bloom time in strawberries is defined as "After Transplanting to the First Harvest." (Note: The crop stage is based on that used in MRD).

California's Code of Regulations, Title 3, currently contains some provisions for pollinator protection that include notifying beekeepers when toxic pesticides will be applied and restricts applications in citrus areas during bloom of certain pesticides that are toxic to bees (Cal DPR, 2014). However, only the notifications, not the bloom-time restrictions, apply to strawberries.

USAGE OF MHATS ON STRAWBERRIES

When taken in total on a seasonal basis, MHAT insecticides constitute approximately 65% of all insecticide treated acres for strawberries (MRD, 2009-2013). MRD (2009-2013) indicate that some applications of insecticides and miticides which are MHAT to bees are being made during bloom time, as presented in Table 13. The top four MHAT insecticides/miticides applied during bloom in terms of average annual total acres treated (2009-2013) includes bifenazate, chlorpyrifos, endosulfan, and abamectin with 13,100, 12,000, 7,500, and 6,900 average annual acres treated, respectively.

Table 13 presents information on the proportion of total acres treated during bloom (defined as "After Transplanting to the First Harvest") for each of these chemicals. These chemicals represent the leading MHAT insecticides used during bloom time on strawberries. These numbers include all treatments across all pests. Abamectin, a miticide which is highly acutely toxic to bees, is used on strawberries but the bulk of these applications occur outside the bloom period. Only about 16% of the total acres treated with abamectin are treated during bloom. Endosulfan is most used miticide during bloom, with 75% of the total treated acres being the bloom time treatment (7,500 acres). But this chemical has since been cancelled, and BEAD projects that bloom-time usage of other miticides, including abamectin will likely increase.

Chlorpyrifos, which is effective in controlling important lepidopteran pests present at bloom time (such as armyworm, beet armyworm, and worms), is used to treat approximately 12,000 acres during bloom, or 90% of total acres treated with this chemical annually. Though a number of MHAT insecticides are used during bloom, market research data indicate that the overall percent crop treated for these chemicals is very low. Abamectin, for example, which is the leading miticide applied to strawberries during bloom, is applied to less than 3% of strawberries annually; even fewer acres are treated with chlorantraniliprole and esfenvalerate (MRD, 2009-2013). Therefore, in estimating a percentage of the total strawberry acreage treated during bloom with one or more MHAT chemicals, BEAD concludes that it would be a minimum of 3%, based on the current usage of abamectin, which is the leading insecticide/miticide used on strawberries during bloom, and a maximum of 8%, which is derived by adding all the strawberry acreage treated with any MHAT chemical during bloom. The low acres treated summarized in Table 13 further indicate that these chemicals are not likely to have a high importance for pest management during bloom. The majority of usage of these chemicals in strawberries occurs during stages outside of bloom stages, with the exception of chlorpyrifos.

Table 13: Strawberries Proportion of Total Acres Treated during Bloom Stages with Insecticides/Miticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages[1]	Total TAT	Bloom Stage Acres Treated as a Percent of Total Acres Treated[2]
BIFENAZATE	13,104	57,339	23%
CHLORPYRIFOS	12,008	13,406	90%

ENDOSULFAN	7,523	10,360	73%
ABAMECTIN	6,861	41,636	16%

[1]*For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'after transplanting to first harvest,' which is indeterminate for strawberries.*
[2] *For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages*
Source: MRD, 2009-2013. Numbers may not add due to rounding.

Table 14 presents an overview of the percent of acres treated during bloom by pest for all insecticides. The first column indicates the importance of bloom stage applications for controlling this type of pest. Overall, 43% of total acres treated for aphids are from applications made during bloom time. Approximately 36% of the acres treated targeting lepidoptera occur during bloom, about 32% of acres treated targeting mites occur during bloom, and about 13% of the acres treated for thrips occur during bloom. The second column indicates the importance of this pest during bloom time relative to other pests. Fifteen percent and 16% of treatments applied to strawberries during the bloom period are targeting Lepidoptera and mites, respectively. Aphids and thrips are relatively less important pests during bloom stages with 5% and 3% of acres of applications targeting these pests, respectively. It should also be noted that while it was not highlighted in usage data, control of plant bugs (*Lygus spp.*) is also very important for strawberry production, particularly for areas with continuous fruit production (UC-IPM, 2012). While the most serious damage is to fruit, the presence of blooms in ever-bearing varieties could preclude adequate control of this pest with mitigation that is based upon the presence of bloom and pollinating bees on site. This situation is somewhat analogous to the plum curculio scenario in eastern apples discussed previously, as most control of this pest occurs outside of bloom periods (MRD, 2009-2013). However, for situations where *Lygus* outbreaks occur during the fruiting/blooming period, MHAT insecticides, such as organophosphates and pyrethroids are most often used for control (MRD, 2009-2013). Further, UC-IPM recommendations for *Lygus* control include mainly MHAT insecticides such as pyrethroids, organophosphates, and neonicotinoids (UC-IPM, 2012). Given low reported usage against this pest during bloom periods, it is not likely that this impact would apply to a large proportion of acreage.

Table 14: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, 2008-2012

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages[1]	Percent of Total Bloom Time Treated Acres by Target Pest[2]
Aphids (aphid, green peach aphid, melon aphid, & strawberry aphid)	43%	5%
Lepidoptera (armyworm, beet armyworm, & worm)	36%	15%
Mites (mite, 2-spotted mite, cyclemen mite, red spider mite, & spider mite)	32%	16%
Thrips (thrip & western flower thrip)	13%	3%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.
[1]*Of all pesticide applications that were made to strawberries throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.*

[2]This number represents the percentage of bloom time pesticide applications on strawberries across all active ingredients that target each pest listed in the Pest column.

OPTION 1: MHAT INSECTICIDE USAGE IS PROHIBITED DURING BLOOM

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

Table 15 compares the current chemical controls used by strawberry growers to chemical controls which would be the likely leading alternatives adopted under the proposed mitigation. For those growers that use MHAT chemicals during bloom stages, there will be expected impacts from the increased cost of switching to non-MHAT insecticide treatments targeting aphids, lepidopteran pests, mites, and thrips. Currently, strawberry growers are likely to use diazinon, imidacloprid, or thiamethoxam (at a cost of approximately $15 per acre) to control aphids. Under the first mitigation option there are no alternative registered chemicals that are effective for aphid or plant bug control, and substantial yield losses could be expected. Chlorpyrifos is used to control lepidopteran pests under the current scenario at a cost of $6 per acre, with 90% of applications occurring during bloom stages. Under mitigation option 1, the likely alternative is methoxyfenozide, at a cost of $14/acre. This would more than double the per acre cost of lepidoptera control compared to chlorpyrifos. Bifenazate is the most widely used pesticide to control mites on strawberries during bloom. Under the proposed mitigation option 1, hexythiazox is the most likely replacement for bifenazate. Switching to hexythiazox may increase costs of production for strawberry growers by $35 per acre for growers targeting mites during bloom periods. For thrips control, strawberry growers use spinosyn under the current scenario at a cost of $28 per acre. No alternative chemicals are available for control of aphids, thrips, and plant bugs in strawberries under mitigation option 1. Thus yield and quality losses are expected. However, at this time, BEAD does not have adequate information to quantify these losses, but projects that given the length of bloom period for many cultivars of strawberries, such losses could be quite large.

Table 15: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Strawberries Option 1

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	Chlorpyrifos	**$6**	Methoxyfenozide,	**$14**
Mites	Abamectin Bifenazate	**$42**	Hexythiazox	**$77**
	Total Chemical Cost, Current Scenario	**$48**	*Total Chemical Cost, Mitigation Scenario*	**$91**
			Potential Additional Yield and Quality Losses from Aphids, Thrips, and Plant Bugs	***Unknown, but likely large***
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($43) + Large Yield Loss**

Numbers may not add due to rounding. Source: MRD, 2008-2012. Prices of active ingredients represent 2008-2012 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. No products are available to control the pests listed in Table 14 that are not applied foliarly. Hence, this is not a viable option for strawberry growers.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios and in situations where control is not possible without MHAT insecticide applications, significant yield loss would be expected if no applications were made of this product.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. For the pests being targeted in these scenarios, some variation in timing to avoid applications during bloom may be possible, particularly mites (after bloom) and aphids/scale (pre-bloom/delayed dormant). For mites, because of the potential for large and sudden outbreaks, exceedance of threshold levels could also sometimes necessitate miticide applications during bloom. For in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures. Further, because plant bugs can occur during both bloom and fruiting periods, inadequate control of plant bugs is likely and significant yield and quality impacts would be expected.

Option 2: Risk-Based Limitations on Pesticide Usage

Table 16 compares the current chemical controls used by strawberry growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal. For growers that rely on MHAT chemicals during bloom stages, and using the revised risk-based approach to identify bee safe insecticides used during bloom based upon likely usage rates, the estimated impact from yield losses from aphids and thrips would be eliminated, due to the availability of acetamiprid. However, potential yield losses from plant bugs are not known, and so the overall impact estimate for scenario 2 could be large.

Table 16: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Strawberries Option 2

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Aphids	Diazinon Imidacloprid Thiamethoxam Acetamiprid	**$8-35**	Acetamiprid	**$32**
Lepidoptera	Chlorpyrifos	**$6**	Methoxyfenozide	**$14**
Mites	Abamectin Bifenazate	**$42**	Bifenazate	**$42**
Thrips	Spinosad Spinetoram Malathion	**$11-50**	Acetamiprid	**$31**
	Total Chemical Cost, Current Scenario	**$67-133**	*Total Chemical Cost, Mitigation Scenario*	**$119**
			Potential Additional Yield and Quality Losses from Plant Bugs	***Unknown, but likely large***
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($0-$52), with some possible expected yield loss**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

Uncertainty: Grower Changes Pollinator Practices.

It is unknown how many strawberry growers utilize commercial pollination services, as it has been reported that practices vary. Some growers claim that commercial honeybees are essential for pollinating strawberries while others have indicated they rarely use pollination services. Although some pollination occurs with native pollinators, contracted honey bees are utilized for some strawberry pollination. However, the extent of contract pollination in this crop is unclear.

STRAWBERRY SUMMARY

BEAD's analysis indicates that mites are a leading driver of abamectin usage during bloom. Lepidopteran pests, which account for the vast majority of treatments applied during bloom, are likely to be treated on more acres. However, due to the availability of diflubenzuron, chlorantraniliprole, and methoxyfenozide (which are not MHAT) for the control of Lepidoptera, the impact of MHAT restrictions is low overall because minimal substitution would be necessary for control of those pests under either mitigation option. Only growers using chlorpyrifos for control of Lepidopteran pests would be expected to see a substitution cost for Lepidopteran pests. This leaves substitution for the control of mites, aphids, thrips, and plant bugs as the main drivers of the projected impact. Growers only needing to target mites via an alternative to abamectin or bifenazate during bloom would be projected to see about a $35 substitution cost under option 1. This substitution cost is eliminated under option 2, due to the availability of bifenazate. Under option 1, growers with pest pressure from aphids and thrips could expect to see large yield losses, though this impact would not be expected to be widespread on an acreage basis. This impact is eliminated under option 2, due to the availability of acetamiprid as an alternative control. While the substitution cost estimate range is slightly higher under option 2 than option 1, some yield losses projected for option 1 are eliminated and in option 2 and this could project to a much lower impact to affected growers overall. However, under both options, control of Lygus bugs is an uncertainty, and could lead to yield losses in some high-pressure instances, due to the long and indeterminate blooming time for strawberry production, albeit again, it is not expected to be widespread on an acreage basis.

Because abamectin is the most widely used miticide during bloom and it is used on about 3% of strawberry acreage during bloom, and approximately 8% of strawberry acres are treated for mites during bloom, it is likely that these projected impacts from substitution costs would affect about 3-8% of strawberry acreage. However, it is unknown how many acres might still be affected by large yield losses associated with plant bugs, which are projected to be possible under either mitigation scenario. An additional uncertainty is what proportion of strawberry growers utilize contracted pollination services. Estimates of total cost impacts were not calculated, due to the uncertainty of the magnitude of potential yield losses from plant bugs over the long indeterminate blooming period for strawberries, which would be the same for both mitigation options.

CANEBERRIES

OVERVIEW

The annual U.S. acreage of caneberries (blackberries and raspberries) are 29,100 acres (MRD, 2009-2013). Washington and Oregon combine to be the major producers of caneberries in the United States, with a combined acreage of 22,800. The next major producer is California, with 6,300 acres planted. For the purposes of this analysis, the bloom time in caneberries is defined as "Bloom through Pre-harvest" as defined by MRD.

California's Code of Regulations, Title 3, currently contains some provisions for pollinator protection that include notifying beekeepers when toxic pesticides will be applied and restricts applications in citrus areas during bloom of certain pesticides that are toxic to bees (Cal DPR, 2014). However, only the notifications, not the bloom-time restrictions, apply to caneberries.

USAGE OF MHATS ON CANEBERRIES

When taken in total on a seasonal and national basis, MHAT insecticides constitute approximately 75% of all insecticide treated acres of caneberries (MRD, 2009-2013). MRD (2009-2013) indicate that some applications of insecticides and miticides which are highly or)MHAT to bees are being made during bloom time, in California, Washington, and Oregon, respectively, as presented in Table 17, 19, and 21. The top MHAT insecticides/miticides applied during bloom in terms of average annual total acres treated (2009-2013) includes spinetoram, bifenazate, malathion, pyrethrins, and bifenthrin. Tables 17, 19, and 21 present information on the number of acres treated and the proportion of total acres treated during bloom for each of these chemicals. These chemicals represent the leading MHAT insecticides used during bloom time on caneberries. These numbers include all treatments across all pests.

For California Caneberries, spinetoram, an insecticide with some broad-spectrum activity, and bifenazate, a miticide, are the most widely used pesticides during bloom, with over half of their total usage occurring during bloom. Malathion and bifenthrin, which are effective in controlling aphids, are used to treat approximately 21,000 combined acres annually during bloom. A number of MHAT insecticides are used during bloom, MRD indicates that the overall percent of crop treated with these chemicals during bloom is near 100%. Furthermore, the relatively high percentage of use on a chemical by chemical basis that occurs during bloom indicates that these chemicals are likely to have a high importance for pest management during bloom on caneberries. The following tables describe MHAT insecticide usage on caneberries for the three leading states for production of raspberries and blackberries.

Table 17: California Caneberries Total Acres Treated and Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2,3]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
Spinetoram	17,669	54%
Bifenazate	11,243	50%
Malathion	17,840	44%
Pyrethrins	3,014	39%
Bifenthrin	2,324	25%

[1] *Note that total acres treated may overestimate the number of acres treated as it does not account for tank mixes that include multiple active ingredients or multiple treatments to the same area. This data is not available for specialty crops.*
[2] *For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages*
3 California average acres grown: 6,313.
Source: MRD, 2009-2013. Numbers may not add due to rounding.

Table 18: California Caneberries: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Percent of Total Bloom Time Treated Acres by Target Pest

WORM	53%	37%
MITE	35%	20%
SPOTTED WING DROSOPHILA	33%	11%
APHID	52%	6%
THRIP	61%	3%
BUG, STINK	65%	2%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.

[1] Of all pesticide applications that were made to caneberries throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.

[2] This number represents the percentage of bloom time pesticide applications on caneberries across all active ingredients that target each pest listed in the Pest column.

Table 19: Washington Caneberries Total Acres Treated Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2,3]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
Spinetoram	5,730	100%
Bifenazate	9,116	90%
Imidacloprid	19,801	86%
Bifenthrin	25,851	43%
Malathion	25,756	37%
Zeta-Cypermethrin	18,426	23%
Diazinon	5,032	18%

[1] Note that total acres treated may overestimate the number of acres treated as it does not account for tank mixes that include multiple active ingredients or multiple treatments to the same area. This data is not available for specialty crops.

[2] Bloom stages.

3 Washington average caneberry acres grown: 11,200.

Source: MRD (add years). Numbers may not add due to rounding.

Table 20: Washington Caneberries: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Percent of Total Bloom Time Treated Acres by Target Pest
WORM	67%	21%
SPOTTED WING DROSOPHILA	33%	16%
APHID	38%	13%
WEEVIL	37%	10%

MITE	67%	6%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.

[1]*Of all pesticide applications that were made to caneberries throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.*

[2]*This number represents the percentage of bloom time pesticide applications on caneberries across all active ingredients that target each pest listed in the Pest column.*

Table 21: Oregon Caneberries Total Acres Treated and Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2,3]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
Spinosyn	1,695	100%
Carbaryl	7,639	99%
Zeta-Cypermethrin	14,337	62%
Esfenvalerate	10,205	61%
Malathion	9,568	51%
Bifenthrin	5,707	25%
Spinetoram	521	15%

[1] *Note that total acres treated may overestimate the number of acres treated as it does not account for tank mixes that include multiple active ingredients or multiple treatments to the same area. This data is not available for specialty crops.*

[2] *For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages*

Source: US EPA Proprietary Data. Numbers may not add due to rounding.

3 Oregon average caneberry acres grown: 11,200.

Table 22: Oregon Caneberries: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Percent of Total Bloom Time Treated Acres by Target Pest
WORM	66%	28%
SPOTTED WING DROSOPHILA	39%	9%
APHID	78%	6%
MITE	20%	3%
WEEVIL	35%	3%
BUG, STINK	100%	2%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.

[1] *Of all pesticide applications that were made to caneberries throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.*
[2] *This number represents the percentage of bloom time pesticide applications on caneberries across all active ingredients that target each pest listed in the Pest column.*

OPTION 1

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

Table 23 compares the current chemical controls used by caneberry growers to chemical controls which would be the likely leading alternatives adopted under the proposed mitigation. Given observed usage of insecticides during bloom periods, it is expected that up to 100% of caneberry acreage would be affected by bloom time restrictions. Growers that use MHAT chemicals during bloom stages would expect to experience impacts from the increased cost of switching to non-MHAT insecticide treatments for mite and Lepidopteran pests. *Bt*, bifenthrin, and spinetoram are used to control lepidopteran pests under the current scenario at a cost of $6-46 per acre, with 90% of applications occurring during bloom stages. Under mitigation option 1, the likely alternatives are tebufenozide or chlorantraniliprole, at a cost of $34/acre. This would significantly increase per acre cost of lepidoptera control compared to bifenthrin, but costs would be comparable to usage of spinetoram. Bifenazate is the most widely used pesticide to control mites on caneberries during bloom. Under the proposed mitigation option 1, hexythiazox is the most likely replacement for bifenazate. Switching to hexythiazox may increase costs of production for caneberry growers by $40 per acre for growers targeting mites during bloom periods. For thrips control, caneberry growers use spinosyn under the current scenario. No alternative chemicals are available for control of thrips in caneberries. Thus, potential yield and quality losses are expected. Currently, caneberry growers are likely to use malathion, bifenthrin, or imidacloprid to control aphids. Under the mitigation scenario there are no alternative registered chemicals that are effective for aphid control, and substantial yield losses could be expected. However, at this time, BEAD does not have adequate information to quantify these losses, but projects that losses from pest damage, particularly for long-blooming varieties of caneberries, could be quite large.

Table 23: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Caneberries Option 1

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	*Bt* Bifenthrin Spinetoram	**$6-46**	*Bt* Tebufenozide, Chlorantraniliprole	**$34**
Mites	Bifenazate	**$49**	Hexythiazox	**$89**
	Total Chemical Cost, Current Scenario	**$55-95**	*Total Chemical Cost, Mitigation Scenario*	**$123**
			Potential Additional Yield and Quality Losses from Aphids and Thrips	***Unknown, but likely large***
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($28-$65) + Large Yield Loss**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. No products are available to control the pests listed in Table 23 that are not applied foliarly. Hence, this is not a viable option for caneberry growers.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios and in situations where control is not possible without MHAT insecticide applications, significant yield loss would be expected if no applications were made of this product.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. For the pests being targeted in these scenarios, some variation in timing to avoid applications during bloom may be possible, particularly mites (after bloom) and aphids/scale (pre-bloom/delayed dormant). For mites or aphids, because of the potential for large and sudden outbreaks, exceedance of threshold levels could also sometimes necessitate miticide applications during bloom. For the other listed pests, and in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures.

OPTION 2

Table 24 compares the current chemical controls used by caneberry growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal. For growers that rely on MHAT chemicals during bloom stages, and using the revised risk-based approach to identify bee safe insecticides used during bloom based upon likely usage rates, the estimated impacts from substitution costs for mites would be less, due to the availability of bifenazate. Further, the large yield losses associated with aphids and thrips would be eliminated, due to availability of acetamiprid for control of these pests during the bloom period.

Table 24: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Caneberries Option 2

Target Pest(s)	**Current Chemical Controls**		**Expected Chemical Controls Under Mitigation**	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	*Bt* Bifenthrin Spinetoram	**$6-46**	*Bt* Tebufenozide, Chlorantraniliprole	**$34**
Mites	Bifenazate	**$49**	Bifenazate	**$49**
Aphids	Malathion Bifenthrin Imidacloprid	**$2-13**	Acetamiprid	**$28**
Thrips	Spinosad Spinetoram Pyrethrins	**$29-46**	Acetamiprid	**$28**
	Total Chemical Cost, Current Scenario	**$86-154**	*Total Chemical Cost, Mitigation Scenario*	**$139**
			Potential Additional Yield and Quality Losses from Aphids and Thrips	**$0**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($0-$53)**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

UNCERTAINTY: GROWER CHANGES POLLINATOR PRACTICES.

The blossoms of most caneberry crops grown require commercial insect pollination services during the bloom period to produce a viable crop. Although some pollination occurs with native pollinators, contracted honey bees are responsible for the majority of caneberry pollination.

CANEBERRY SUMMARY

Due to the availability of chlorantraniliprole, and tebufenozide (which are not MHAT) for the control of Lepidoptera, the impact of MHAT restrictions is low overall with regard to this pest complex, because minimal substitution costs would be projected for control under either option. Growers only needing to target mites via an alternative to bifenazate during bloom would be projected to see about a $40 substitution cost under option 1. This substitution cost is eliminated under option 2, due to the availability of bifenazate. Under option 1, growers with pest pressure from aphids and thrips could see large yield losses. This impact is eliminated under option 2, due to the availability of acetamiprid as an alternative control. While the substitution cost estimate range is slightly higher under option 2 than option 1, the yield losses projected for option 1 are eliminated and option 2 projects to a much lower impact to affected growers overall. Because MHATs are widely used on caneberries during bloom, BEAD projects that the estimated impacts would impact nearly 100% of caneberry acreage in the United States.

Given current usage patterns, it is likely that these projected impacts would affect nearly all caneberry production, which totals 29,100 acres. Under mitigation option 1, a total impact estimate is not calculated, due to the uncertainty regarding the likely large yield losses that would be incurred due to damage from aphids and thrips. Under mitigation option 2, assuming the upper-bound impact of $53 for substitution costs to non-toxic insecticides, total impact to caneberry growers would be approximately $1.5 million.

BLUEBERRIES AND CRANBERRIES (QUALITATIVE ANALYSIS)

Overview

Michigan is the largest production state in the U.S. for highbush blueberries, with approximately 19,000 acres grown (USDA-NASS, 2014). Other significant production states include New Jersey (9,000 acres), Georgia (13,000 acres), Oregon (8,000 acres), North Carolina (6,000 acres), and Florida (4,000 acres). It should be noted that Maine produces lowbush blueberries on approximately 23,000 acres annually. However, it should also be noted that lowbush blueberries (i.e., 'wild' blueberries) in Maine are produced in a biennial cycle, with harvest occurring only every other season, and so the total acreage is actually around double that figure (Yarborough, 2009). Massachusetts (13,000 acres) and Wisconsin (19,000 acres) are the leading producers of cranberries, with approximately 2,000 acres of cranberries also grown in Washington and smaller levels of production in Oregon.

Both highbush and lowbush blueberry growers as well as many cranberry growers make use of commercial pollinations services, though the relative proportion of growers doing so is unknown. Depending on the geographic region, bloom timing and duration can vary. For lowbush blueberries in Maine, bloom typically begins in early May and lasts 2-4 weeks (Yarbrough, 2009). For highbush blueberries grown in Michigan, bloom typically occurs between late April and early June (Garcia-Salazar, 2002). Bloom timing for berries grown in the southern U.S. would be earlier. Cranberries in the east and midwest typically bloom between mid-June and early July, for a period of 3-6 weeks (UMass, 2016) while cranberries grown in the Pacific Northwest have an earlier onset of bloom in early June, the duration of bloom is similar at 3-6 weeks (Oregon State University, 2002).

One significant regional production difference is that cranberries grown in the Pacific Northwest are not typically flooded for pest control or over winter. This difference has an important effect on insect populations, particularly control of black vine weevils in Washington, which are controlled in most areas by bog flooding.

USAGE OF MHATS ON BLUEBERRIES AND CRANBERRIES AND QUALTITATIVE ASSESSMENT

No crop-stage specific pesticide usage data are available for blueberries or cranberries in the proprietary MRD utilized by BEAD. Therefore, BEAD relied on selected land-grant university extension service publications (pest management guides, grower-oriented pest advice newsletters, etc), USDA crop profiles and Pest Management Strategic Plans (documents maintained online by four regional IPM Centers, and available via ipmcenters.org), and BEAD staff's best professional judgement. Discussions of target pests and management options follows below on a regional basis. Separation of the discussion by major production region is appropriate for these crops since the pest spectrum and/or crop varieties are different across these areas.

Highbush blueberries (focusing on Michigan production)

This section focuses on the insect pests likely targeted by insecticide use close to or during bloom in highbush (also called "tame") blueberry production in Michigan. This state is one of the largest producers of these berries in the U.S., and BEAD projects that it is a reasonable representative of the pest management picture in other mid-Western states that are also producers of the crop (e.g., Indiana, Ohio).

Based on the sources described above, BEAD concluded that for economically significant (and thus frequent) insect pests needing management with pesticides around bloom include caterpillars (mainly the cherry and cranberry fruitworms [*Grapholita packardii* and *Acrobasis vacinii*, respectively]), and the Obliquebanded leafroller (*Choristoneura rosaceana*, to a lesser extent). Fruitworms lay their eggs on developing berries (just after petal-fall); the larvae that hatch then burrow inside the developing fruit and emerge only occasionally to move to fresh fruit clusters. Leafrollers represent a threat mainly to the foliage, and large numbers can reduce yield and quality. While the larvae infest fruit after bloom, fruitworm adults are targeted by growers using insecticides near bloom mainly because the larvae are difficult to detect or reach with contact insecticides, and because there is zero tolerance for insect infestations in either fresh or processed fruit. Both fruitworm and leafroller adult female populations can rise near or during the bloom period.

MHAT insecticides that are likely to be used for caterpillar control in highbush blueberries grown in Michigan include phosmet, diazinon (both are not recommended during bloom, but could be used by some growers); and spinosad. "Non-MHAT" insecticides that are reasonably effective options include methoxyfenozide, tebufenozide, "Grandevo" (a new biopesticide containing the entomopathogenic bacterium *Chromobacterium subtsugae*), pyriproxyfen, and novaluron. BEAD does not anticipate significant yield or quality losses for most growers with use of the alternatives, although production costs may rise due to both the substitution costs and the expense of making more than one application to be protective. Under mitigation option 2, acetamiprid and indoxacarb are also available for control of Lepidopteran pests, as well as for control of less frequent pests such as aphids and thrips.

Highbush and "rabbiteye" blueberries (grown in New Jersey, North Carolina, Florida, and other eastern regions except Michigan).

Rabbiteye blueberries are a type of highbush blueberry that tolerates heat and fewer winter chilling hours (a requirement for adequate flower production) better than varieties grown in northern regions. It is not a major variety in New Jersey blueberry production but is included in this section because of the mention of thrips as a bloom-time pest problem in the state. Thrips are also an occasionally significant problem in blueberry production in southeastern states. For unknown reasons, thrips are rarely a problem in Michigan blueberries (Isaacs, 2011). Several different species of thrips can attack blueberries, including the blueberry thrips (*Frankliniella vacinnii*), flower thrips (*F. tritici*), eastern flower thrips (*Scirtothrips ruthveni*), and others. While thrips feeding can reduce pollination and fruit set and damage leaves, the impact on yield and fruit quality is poorly understood, and no economic thresholds for treatment have been developed.

While widespread intense thrips damage seems to be relatively rare in this crop in most years, there could be an unknown level of yield and quality loss in some areas if pest populations are high and no insecticides (e.g., diazinon, malathion, and imidacloprid) can be used during bloom. To try to balance the rarity of severe thrips infestations against the typically low occurrence of this pest complex, BEAD estimates that a 1-2 % yield and/or quality loss could occur without insecticide control as an option. Under option 2, acetamiprid is available for control of Lepidopteran pests, as well as control of thrips and aphids, which mitigates any impact from these pests.

Lowbush (= "wild") blueberries (grown in Maine, Massachusetts, and Vermont)

This type of blueberry is grown on a two year cycle, and is commercially productive only in New England states. The University of Maine (2016) summarizes the crop cycle as follows: "each year, half of a grower's land is managed to encourage vegetative growth and the other half is prepared for a wild blueberry harvest in August. After the harvest, the plants are pruned to the ground by mowing or burning." Most of this crop is grown in Maine, with much smaller acreage in other nearby states.

In terms of insects pests near or during bloom, lowbush blueberries are similar in many ways to the highbush crop. In addition to the caterpillars that attack those types of blueberries, lowbush blueberry growers may also need to control larvae of the spanworm, which is likely to be controlled by many of the same materials that are effective against other Lepidopteran pests. In addition, lowbush growers may also need to control thrips (of the same species as those discussed above), and the blueberry flea beetle (*Altica sylvia*).

For thrips, "MHAT" insecticides that are currently recommended include diazinon, malathion, and imidacloprid. While no "non-MHAT" insecticides are recommended, lowbush blueberries do allow two apparently feasible cultural and alternative insecticidal control tactics, due to their unusual two-year crop cycle. One is to allow thrips to emerge during the fallow ("pruned") year, colonize leaves, and then burn the plants to simultaneously prune and kill the pests (University of Maine, 2016). The other is to apply a soil drench of imidacloprid or other neonicotinoid in the "pruned" year. However, this tactic requires a great deal of water and is recommended only for heavily infested patches.

The blueberry flea beetle appears to be an occasional pest of economic importance. The University of Maine (2016) describes their impact as follows: "Flea beetle larvae feed on blueberry leaves and blossoms from mid-May through June; the adults feed on foliage beginning in late June or early July." For this insect, MHAT insecticides recommended include carbaryl, phosmet, spinetoram, acetamiprid, and spinosad. Non-toxic insecticide option include: *Bt* and Botanigard (a biopesticide containing the entomopathogenic fungus *Beauveria bassiana*). The efficacy of these options as compared to the MHAT insecticides is unclear.

Beyond these control options, growers of this crop can also utilize pruning in the non-bearing year to reduce flea beetle populations for the subsequent (producing) year. The reliability of this strategy as an alternative to insecticide control is not clear. However, given the apparently rare occurrence of seriously damaging flea beetle populations, BEAD projects that most growers will not face significant yield or quality losses due to these pests. For thrips, which appear to be more common than flea beetles, BEAD concludes, in line with the conclusion for highbush blueberries that the 1-2 % loss described for highbush blueberries is applicable to the lowbush crop as well for mitigation option 1. Under mitigation option 2, acetamiprid is available for control of Lepidopteran pests, as well as control of thrips and aphids, so yield loss is not expected.

Cranberries grown in Massachusetts and Wisconsin

Cranberry growers in these regions may face the need to use insecticides to control a suite of caterpillars close to or during bloom. These insects include the blackheaded fireworm (*Rhopobota naevana*), cranberry fruitworm, and the Sparganothis fruitworm (*Sparganothis sulfureana*). The cranberry fruitworm feeds only on the fruit; adults are present before and during bloom, and lay eggs on developing berries (Mahr, 2005a). Once hatched, larvae burrow into developing berries and move only when their food source is exhausted (similar to their behavior in blueberries). There is one generation per year.

Both the blackheaded fireworm and the Sparganothis fireworm have two generations per year in most regions. The first generation of larvae feed mainly on cranberry foliage and can reduce yield by webbing together and otherwise damaging leaves. The second generation feeds on both foliage and fruit and thus poses a threat to harvest quality, much like the cranberry fruitworm does (Mahr, 2005b). MHAT insecticides likely to be used against this complex of insect pests include pyrethrins and spinosad. However, there are non-MHAT insecticides also recommended for all these insects; these include *Bt*, chlorantraniliprole, and methoxyfenozide. Given the availability of these control options, BEAD concludes that significant yield/quality losses are not likely, though substitution costs may drive some impact to growers.

Cranberries grown in the Pacific Northwest (mainly Washington)

Similar to the midwest, growers in this region face two caterpillars that need control close to or during bloom: the blackheaded fireworm and cranberry fruitworm. Damage, insecticide control options, and BEAD's conclusions regarding labeling impacts are identical to that described for other cranberry growing regions above.

The black vine weevil (*Otiorhynchus sulcatus*) and the strawberry root weevil (*O. ovatus*) are other pests that may occur (as feeding larvae and ovipositing adults) close to or during cranberry bloom and require insecticidal control. The larvae cause the economic damage by feeding on the roots of plants and reducing plant health and subsequent yield. Damage usually becomes apparent just before or during bloom (Oregon State University, 2016). Control can be directed against either the larvae or the adults (or both). The most widely recommended MHAT insecticide is indoxacarb, which only targets the egg-laying adults. There are no non-toxic insecticides recommended for these pests. However, there are several options for managing them outside the bloom period, including imidacloprid, clothianidin, Grandevo, and entomopathogenic nematodes (Oregon State University, 2016). Some of these can be applied as soil treatments to target the larvae. While increased use of these non-bloom alternatives to replace foliar insecticides (targeting adults) should be factored in, BEAD does not expect yield/quality losses if bloom-time restrictions are placed on indoxacarb. Under option 2, indoxacarb is available for control of black vine weevils during bloom, which would negate any significant impact of substitution costs, since this is already a leading choice for control of this pest.

Cucurbit Crops

For analysis of cucurbits, a number of representative crops were chosen for this analysis, based upon their known reliance on pollination services and public comments that indicated impacts of bloom-time restrictions would be significant. Representative crop scenarios include cantaloupes (California), cucumbers (Michigan and Florida), pumpkins (Illinois), and squash (California, Florida, and Michigan) and it is projected that these scenarios are largely representative for most of the major growing regions of the United States. The majority of cucurbit crops require pollination by honey bees. Cucurbit crops bloom indeterminately, thus pollinators may be at greater risk of exposure to MHAT chemicals during the entire period of vining to harvest.

Cantaloupes (California)

California is the main cantaloupe producing state in the U.S. with approximately 39,000 acres of cantaloupes grown in 2010 (USDA NASS, Ag Stats 2011). In California the primary production acres for cantaloupes are in the southern desert valleys (Imperial and Riverside counties) and the San Joaquin Valley (Fresno, Kern, Kings, Merced, and Stanislaus counties) (Hartz, et al., 2008). Cantaloupes, like all cucurbits, are indeterminate bloomers and are in bloom from vining through harvest. California growers plant from February through June, in order to have melons from May through October (Hartz, et al. 2008).

USAGE of MHATs on Cantaloupes

When taken in total on a seasonal and national basis, MHAT insecticides constitute approximately 82% of all insecticide treated acres for cantaloupes (MRD, 2009-2013). Market research data (MRD, 2009-2013) indicate that some applications of insecticides and miticides which are highly or moderately acutely toxic to bees are being made during bloom time (Table 25). The top four MHAT insecticide/miticides applied during bloom include bifenthrin, abamectin, acetamiprid, and methomyl, with about 103,000, 80,000, 45,000, and 32,000 total acres treated during bloom, respectively, indicating multiple applications of these products over the same acreage.

The overall percentage of acreage treated with MHAT chemicals is high. For example, bifenthrin, which was applied to over 100,000 acres during vining to harvest in 2009-2013, was applied to approximately 51% of all cantaloupe acreage during this time period. Up to 100% of cantaloupe acreage is treated with at least one MHAT insecticide during vining to harvest. Bifenthrin, a broad-spectrum synthetic pyrethroid, targets several insect pests in cantaloupes, including lepidopteran larvae, hemipterans, and beetles.

Table 25: California Cantaloupes: Proportion of Total Acres Treated during Bloom Stages with Insecticides/Miticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages[1]	Bloom Stage Acres Treated as a Percent of Total Acres Treated[2]

ABAMECTIN	80,327	23%
ACETAMIPRID	45,439	90%
BIFENTHRIN	103,085	73%
METHOMYL	31,932	16%

[1]For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'vining to harves' which is indeterminate for cucurbits.
[2] For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages.
Source: MRD, 2009-2013. Numbers may not add due to rounding.

MRD indicate that lepidopteran pests, mites, leafminers, and hemipteran pests (e.g., aphids and whiteflies) are the most important pests in terms of total acres treated during bloom (Table 26). The first column indicates the importance of bloom stage applications for controlling this type of pest. The second column indicates the importance of this pest during vining to harvest relative to other pests. Overall, 72% of treatments for lepidopteran pests occur during vining to harvest. Treatments for hemipteran pests during bloom constitute 49% of all treatments. Furthermore, lepidopteran pests are the most important insect pests in cantaloupes, as treatments for lepidopteran pests represent about 55% of acreage treated with pesticides during vining to harvest.

Table 26: California Cantaloupes: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, 2009-20113

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages[1]	Percent of Total Bloom Time Treated Acres by Target Pest[2]
Lepidoptera	72%	55%
Mites	65%	17%
Whiteflies/Aphids	49%	39%
Leafminer	78%	11%
Thrips	38%	1%
Coleoptera	18%	3%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.
[1]Of all pesticide applications that were made throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.
[2]This number represents the percentage of bloom time pesticide applications on apples across all active ingredients that target each pest listed in the Pest column.

OPTION 1

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

Table 27 compares the current chemical controls used by cantaloupe growers to chemical controls which would be the likely leading alternatives adopted under the proposed mitigation. As was discussed previously, the percentage of overall treatments with MHAT insecticides that occur during bloom is very high, with up to 100% of acreage treated during bloom for important pests.

For growers that use MHAT chemicals during bloom stages, there will be expected impacts from the increased cost of switching to non-MHAT insecticide treatments targeting Lepidopteran pests. Substitution costs for Lepidopteran pests will be expected to be low to negligible, since most growers are already using non-MHAT materials to target these pests. More critically, under mitigation option 1, there are no alternative registered chemicals that are effective for control of aphids, thrips, leafminers, mites, or other hemipterans such as plant bugs and stink bugs. For growers affected by these pests, substantial yield losses could be expected. Such losses could be further compounded by the inability to control pests that vector viral diseases (such cucumber mosaic virus, etc.), and in some instances, failure to mitigate such risks could lead to a total loss of production.

Table 27: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation under Option 1 for California Cantaloupes

Target Pest(s)	**Current Chemical Controls**		**Expected Chemical Controls Under Mitigation**	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	Methoyxfenozide Bifenthrin Chlorantraniliprole	**$5-23**	Methoxyfenozide Chlorantraniliprole	**$14-23**
	Total Chemical Cost, Current Scenario	**$5-23**	*Total Chemical Cost, Mitigation Scenario*	**$14-23**
			Potential Additional Yield and Quality Losses from Aphids, Leafminers, Hemiptera, Mites, and Thrips	***Unknown, but likely very large. Up to 100% total losses***
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($0-18) + Large Yield Loss**

Numbers may not add due to rounding. Source: MRD, 2008-2012. Prices of active ingredients represent 2009-2013 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. It is possible that some systemic insecticides (i.e., neonicotinoids) applied via soil drench might provide efficacy against aphids and thrips. MRD (2009-2013) indicate that soil drench applications are made to cucurbits, but only foliar alternatives were considered for this analysis.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios and in situations where control is not possible MHAT insecticide applications, significant yield loss would be expected if no applications were made of this product.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. Due to the extended period of bloom for cucurbits, it is unlikely that delayed timing would provide adequate protection for direct-feeding pests. For mites or aphids, because of the potential for large and sudden outbreaks, exceedance of threshold levels could also sometimes necessitate miticide applications during bloom. For the other listed pests, and in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures.

OPTION 2: RISK-BASED LIMITATIONS ON PESTICIDE USAGE

Table 28 compares the current chemical controls used by cantaloupe growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal. Certain active ingredients may be available to growers if they are applied below rates that are moderately harmful and acutely toxic to pollinators (Table 28). For example, acetamiprid may be used to control aphids, and a number of miticides would be available to control mites. While substitution costs for control of Lepidopteran pests would remain mostly unchanged, the large yield losses associated with aphids and mites, wouldbe eliminated, due to the availability of acetamiprid and bifenazate for control of these pests during bloom. Potential yield losses are still possible from thrips, leafminers, and Hemipterans, though applications targeting these pests during bloom periods account for a relatively small proportion of acreage (MRD, 2009-2013).

Table 28: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation for California Cantaloupes under Option 2

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	Methoyxfenozide Bifenthrin Chlorantraniliprole	**$5-23**	Methoxyfenozide Chlorantraniliprole	**$14-23**
Mites	Abamectin Bifenthrin	**$6-10**	Spiromesifen Fenpyroximate Bifenazate	**$25-49**
Aphids/Whiteflies	Imidacloprid Acetamiprid Bifenthrin Thiamethoxam	**$6-25**	Acetamiprid	**$18**
	Total Chemical Cost, Current Scenario	**$16-46**	*Total Chemical Cost, Mitigation Scenario*	**$68-92**
			Potential Additional Yield and Quality Losses from Thrips Leafminers, and other Hemiptera	**Unknown**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($22-$76) + Significant Yield Losses**

Numbers may not add due to rounding. Source: MRD, 2008-2012. Prices of active ingredients represent 2009-2013 5-year average.

UNCERTAINTY: GROWER CHANGES POLLINATOR PRACTICES.

The blossoms of cucurbit crops require commercial insect pollination services during the bloom period to produce a viable crop. Although some pollination occurs with native pollinators, contracted honey bees are responsible for the majority of cucurbit pollination.

Cucumbers (Michigan, Florida)

An average of 124,000 acres of cucumbers are planted each year in the U.S. (2009-2013 average, USDA NASS). Michigan and Florida produce the most cucumbers of all states, with approximately 33,000 and 30,000 acres of cucumbers harvested each year (2009-2013 average, USDA NASS). These two states account for about half of all cucumber production in the U.S. Michigan produces predominantly cucumbers for processing, while Florida produces mostly fresh market cucumbers. For the purposes of this analysis, bloom time in cucumbers is defined as "from vining to harvest."

MHAT Usage on Cucumbers

When taken in total on a seasonal and national basis, MHAT insecticides constitute approximately 68% of all insecticide treated acres for cucumbers (MRD, 2009-2013). MRD indicate that some applications of insecticides that are highly or moderately acutely toxic to bees are applied to cucumbers from vining to harvest.

The most used MHAT insecticides used on Michigan cucumbers include permethrin, esfenvalerate, and cyfluthrin, with 22,941, 9,038 and 8,384 TAT during bloom from 2009-2013, respectively (Table 29). Permethrin, esfenvalerate, and cyfluthrin are broad-spectrum, contact insecticides that control lepidopteran and hemipteran pests in cucumbers. Of all of the MHAT insecticides used on cucumbers, permethrin is used on more than double the acreage of the second most-used MHAT insecticide. Permethrin is effective against aphids, cucumber beetles, flea beetles, loopers, lygus bug, squash bugs, thrips and whiteflies.

Proprietary data indicate the overall crop treated percentage for most of these chemicals in Michigan is fairly high. The lowest bloom stage acres treated as a percentage of total acres treated occurred for bifenthrin (Table 29). The use of acetamiprid, methomyl, and spinetoram only occurred during vining to harvest. Almost two-thirds of all permethrin treatments in Michigan occurred during vining to harvest. The overall percent of the cucumber crop treated with MHAT chemicals is high. About 45% of Michigan cucumber acreage is treated with an MHAT insecticide during vining to harvest, assuming that the same area is not treated with multiple pesticide active ingredients (AIs) during this period. In estimating a percentage of the total Michigan cucumber acreage treated during vining to harvest with one or more MHAT chemicals, BEAD concludes that it would be a minimum of 21% and a maximum of 45%.

Table 29: Michigan Cucumbers Total Acres Treated and Proportion of Total Acre Treated During Bloom Stages with MHAT Insecticides, 2009-2013.

Active Ingredient	Total Acres Treated, Bloom Stages [1,2]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
ACETAMIPRID	596	100%
BIFENTHRIN	3,360	15%
CYFLUTHRIN	8,384	81%
CYHALOTHRIN-LAMBDA	3,198	44%
ENDOSULFAN	2,091	26%
ESFENVALERATE	9,038	43%
PERMETHRIN	22,941	66%
SPINETORAM	472	100%

[1]*For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'vining to harvest' which is indeterminate for cucurbits.*
[2]*For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages.*
Source: MRD, 2009-2013. Numbers may not add due to rounding.

MRD for Michigan indicate that cucumber beetle, lepidoptera species, mites, thrips, and aphids are the most important pests in terms of total acres treated during bloom (Table 30). The first column indicates the importance of bloom stage applications for controlling this type of pest. The second column indicates the importance of this pest during vining to harvest relative to other pests. Overall, 100% of treatments for mites and thrips occurs during vining to harvest. Treatments for cucumber beetles during bloom constitute 42% of all treatments. Furthermore, cucumber beetle is the most important insect pest in cucumbers, as treatments for cucumber beetle represent about 4% of all pesticide treatments acreage during bloom.

Table 30: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, on Michigan Cucumbers 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Percent of Total Bloom Time Treated Acres by Target Pest
BEETLE, CUCUMBER	42%	4%
LEPIDOPTERA	25%	0%
MITES	100%	0%
THRIP	100%	0%
APHIDS	19%	0%

Source: Market Research Data, 2009-2013.. Numbers may not add due to rounding.
[1]Of all pesticide applications that were made throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.
[2]This number represents the percentage of bloom time pesticide applications on Michigan cucumbers across all active ingredients that target each pest listed in the Pest column.

Pest pressures and preferred treatment options in Florida cucumbers are markedly different than in Michigan cucumbers. Furthermore, most cucumbers grown in Florida are for the fresh market, rather than the processing market. The two most dominant MHAT insecticides in Florida cucumber production are indoxacarb and methomyl, both of which were used on over 30,000 acres during vining to harvest from 2009-2013 (Table 31). Insecticides that were used on over 10,000 acres from 2009-2013 include bifenazate, bifenthrin, endosulfan, and naled.

MRD suggest that the overall crop treated percentage for most of these chemicals are high. The lowest bloom stage acres treated as a percentage of total acres treated occurred for permethrin (Table 31). Unlike certain AIs in Michigan cucumbers, no single MHAT insecticide was used exclusively during bloom time. Endosulfan constitutes that largest proportion of vining to harvest acres treated as a percent of total acres treated at 78% (Table 30). All MHAT insecticides, except permethrin, had over 30% of vining to harvest treated as a percent of the total acres treated (TAT) with each chemical. The overall percentage of cucumber acres treated with MHAT chemicals is high. For example, indoxacarb, which was applied to over 35,000 acres during vining to harvest in 2009-2013, was applied to approximately 23% of all cucumber acreage during this time period. Up to 100% of Florida cucumber acreage is treated with an MHAT insecticide during vining to harvest. In estimating a percentage of the total Florida cucumber acreage treated during vining to harvest with one or more MHAT chemicals, BEAD concludes that it would be a minimum of 23% and a maximum of 100%.

Table 31: Florida Cucumbers Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
AZADIRACHTIN	8,343	49%
BIFENAZATE	13,560	63%
BIFENTHRIN	10,953	34%
DIAZINON	3,704	30%
ENDOSULFAN	16,645	78%
ESFENVALERATE	9,146	33%
FENPROPATHRIN	4,481	56%
INDOXACARB	35,413	51%
MALATHION	2,173	50%
METHOMYL	34,539	48%
NALED	12,583	63%
PERMETHRIN	6,815	29%
PYRETHRINS	1,435	50%
SPINETORAM	5,258	44%
THIAMETHOXAM	4,497	34%

[1]For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'vining to harvest' which is indeterminate for cucurbits.
[2] For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages.
Source: MRD, 2009-2013. Numbers may not add due to rounding.

Market research data indicate that cucumber and flea beetles, lepidopteran species, mites, thrips, leafminers, flies, and hemipteran species are the most important pests in terms of total acres treated during bloom on Florida Cucumbers (Table 32). The first column indicates the importance of bloom stage applications for controlling this type of pest. The second column indicates the importance of this pest during vining to harvest relative to other pests. Overall, 86% of treatments for lepidopteran pests occur during vining to harvest. Treatments that target Lepidoptera species constitute 51% of all treatment acreage during vining to harvest.

Table 32: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, on Florida Cucumbers 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Percent of Total Bloom Time Treated Acres by Target Pest
CUCUMBER/FLEA BEETLES	53%	3%
LEPIDOPTERA	86%	51%
MITE	44%	3%
THRIP	46%	2%

LEAFMINER	37%	1%
FLY	50%	1%
HEMIPTERA	36%	11%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.

[1]*Of all pesticide applications that were made throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.*

[2]*This number represents the percentage of bloom time pesticide applications on apples across all active ingredients that target each pest listed in the Pest column.*

OPTION 1

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

Table 33 compares the current chemical controls used by cucumber growers to chemical controls which would be the likely leading alternatives adopted under the proposed mitigation. As was discussed previously, the percentage of overall treatments with MHAT insecticides that occur during bloom is very high, with up to 100% of acreage treated during bloom for important pests in Florida.

For growers that use MHAT chemicals during bloom stages, there will be expected impacts from the increased cost of switching to non-MHAT insecticide treatments targeting Lepidopteran pests. Substitution costs for Lepidopteran pests will be expected to be small to negligible, since most growers are already using non-MHAT materials to target these pests. More critically, under mitigation option 1, there are no alternative registered chemicals that are effective for control of cucumber beetles, aphids, thrips, mites, or other hemipterans such as plant bugs and stink bugs. For growers affected by these pests, substantial yield losses could be expected. Such losses could be further compounded by the inability to control pests that vector viral diseases (such as cucumber mosaic virus, etc.), and in some instances, failure to mitigate such risks could lead to a total loss of production.

Table 33: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Cucumbers Option 1

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	Flubendiamide Indoxacarb Methomyl Methoxyfenozide	**$12-16**	Methoxyfenozide Chlorantraniliprole	**$16-37**
	Total Chemical Cost, Current Scenario	**$12-16**	*Total Chemical Cost, Mitigation Scenario*	**$16-37**
			Potential Additional Yield and Quality Losses from Cucumber Beetles, Aphids, Thrips, and Mites	***Unknown, but likely very large. Up to 100% total losses***
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($0-25) + Large Yield Loss**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. It is possible that some systemic insecticides (i.e., neonicotinoids) applied via soil drench might provide efficacy against aphids and thrips. MRD (2009-2013) indicate that soil drench applications are made to cucurbits, but only foliar alternatives were considered for this analysis.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios and in situations where control is not possible without MHAT insecticide applications, significant yield loss would be expected if no applications were made of these products.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. Due to the extended period of bloom for cucurbits, it is unlikely that delayed timing would provide adequate protection for direct-feeding pests. For mites or aphids, because of the potential for large and sudden outbreaks, exceedance of threshold levels could also sometimes necessitate miticide applications during bloom. For the other listed pests, and in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures.

OPTION 2: RISK-BASED LIMITATIONS ON PESTICIDE USAGE

Table 34 compares the current chemical controls used by cucumber growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal. Certain MHAT active ingredients may be available to growers if they are applied below rates that are moderately harmful and acutely toxic to pollinators (Table 34). For example, acetamiprid may be used to control cucumber beetles and indoxacarb may be used to control lepidopteran pests at lower rates. . While substitution costs for control of Lepidopteran pests would remain mostly unchanged, substitution costs for other pests due increase, as acetamiprid is a relatively expensive alternative. However, the large yield losses associated with aphids, mites, and cucumber beetles would be eliminated, due to the availability of acetamiprid for control of these pests during bloom. Potential yield losses are still possible from thrips and Hemipterans, though applications targeting these pests during bloom periods account for a relatively small proportion of acreage.

Table 34: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Cucumbers Option 2

Target Pest(s)	**Current Chemical Controls**		**Expected Chemical Controls Under Mitigation**	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Cucumber Beetle	Permethrin Imidacloprid Esfenvalerate	**$5-18**	Acetamiprid	**$23**
Lepidoptera	Flubendiamide Indoxacarb Methomyl Methoxyfenozide	**$12-16**	Methoxyfenozide Chlorantraniliprole Indoxacarb	**$15-37**
Mites	Bifenazate Bifenthrin Azadirachtin	**$16-48**	Bifenazate	**$25-43**
Aphids/Whiteflies	Esfenvalerate Permethrin Methomyl	**$6-16**	Acetamiprid	**$23**
	Total Chemical Cost, Current Scenario	**$39-98**	*Total Chemical Cost, Mitigation Scenario*	**$86-126**
			Potential Additional Yield and Quality Losses from Thrips and other Hemiptera	**Unknown**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($0-87) + Yield Losses**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

UNCERTAINTY: GROWER CHANGES POLLINATOR PRACTICES.

The blossoms of cucurbit crops require commercial insect pollination services during the bloom period to produce a viable crop. Although some pollination occurs with native pollinators, contracted honey bees are responsible for the majority of cucurbit pollination.

Pumpkin (Illinois)

Illinois produces more pumpkins than any other state with an average of 18,220 acres harvested from 2010-2014 (USDA NASS, 2014). The top producing counties in Illinois are Tazewell, Mason, Peoria, and Wayne (USDA, 2012).

The MHAT insecticides most used in Illinois pumpkins include bifenthrin, cyhalothrin-lambda, and endosulfan, with 5,248, 1,068 and 1,823 TAT during bloom from 2009-2013 (Table 34). Bifenthrin, cyhalothrin-lambda, and endosulfan are broad-spectrum insecticides that control lepidopteran and hemipteran pests in pumpkins. Of all of the MHAT insecticides used on pumpkins, bifenthrin is used on more than double the acreage of the second most-used MHAT insecticide. Bifenthrin is effective against aphids, cucumber beetles, flea beetles, loopers, lygus bug, squash bugs, thrips and whiteflies.

MHAT Usage in Pumpkins

When taken in total on a seasonal and national basis, MHAT insecticides constitute nearly 100% of all insecticide treated acres for pumpkins (MRD, 2009-2013). MRD indicate the overall crop treated percentage for most of these chemicals is fairly high. According to the data, in Illinois, over half of all bifenthrin treatments occurred during vining to harvest (Table 35). The overall PCT for MHAT chemicals is relatively high. However, bifenthrin, which is the leading insecticide applied to cucumbers from 2009-2013, was applied to only 6% of all pumpkin acreage during that time period. About 10% of pumpkin acreage was treated with an MHAT insecticide during vining to harvest, assuming that the same area is not treated with multiple AIs during this period. In estimating a percentage of the total Illinois pumpkin acreage treated during vining to harvest with one or more MHAT chemicals, BEAD therefore concludes that it would be a minimum of 6% and a maximum of 10%.

Table 35: Illinois Pumpkin Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
BIFENTHRIN	5,248	57%
CYHALOTHRIN-LAMBDA	1,064	93%
ENDOSULFAN	1,823	100%

[1]For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'vining to harves' which is indeterminate for cucurbits.
[2] For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages.
Source: MRD, 2009-2013. Numbers may not add due to rounding.

MRD for Illinois (2009-2013) indicate that lepidopteran species, coleopteran, and hemipteran species are the most important pests in terms of total acres treated during bloom (Table 36). The first column indicates the importance of vining to harvest applications for controlling specific pests. The second column indicates the importance of this pest during vining to harvest relative to other pests. Treatments targeting hemipteran pests, such as aphids and squash bugs, constitute 68% of treated acres during vining to harvest. Furthermore, treatments targeting hemipteran pests account for 4% of all treated acres by target pest.

Table 36: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, Illinois Pumpkins 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Percent of Total Bloom Time Treated Acres by Target Pest
Lepidoptera	16%	0%
Coleoptera	23%	1%
Hemiptera	68%	4%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.
[1]Of all pesticide applications that were made throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.
[2]This number represents the percentage of bloom time pesticide applications on Illinois pumpkins across all active ingredients that target each pest listed in the Pest column.

OPTION 1

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

Table 37 compares the current chemical controls used by pumpkin growers to chemical controls which would be the likely leading alternatives adopted under the proposed mitigation. As was discussed previously, the percentage of overall treatments with MHAT insecticides that occur during bloom is relatively low, with approximately 10% of acreage treated during bloom for important pests.

For growers that use MHAT chemicals during bloom stages, there will be expected impacts from the increased cost of switching to non-MHAT insecticide treatments targeting Lepidopteran pests. Substitution costs for Lepidopteran pests will be expected to be negligible, since most growers are already using non-MHAT materials to target these pests. More critically, under mitigation option 1, there are no alternative registered chemicals that are effective for control of cucumber beetles, aphids, thrips, mites, or other hemipterans such as plant bugs and stink bugs. For growers affected by these pests, substantial yield losses could be expected, however such losses would affect a relatively small proportion of acreage. Such losses could be further compounded by the inability to control pests that vector viral diseases (such as cucumber mosaic virus, etc.), and in some instances, failure to mitigate such risks could lead to a total loss of production.

Table 37: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Pumpkin Option 1

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	Flubendiamide Indoxacarb Methomyl Methoxyfenozide	**$12-16**	Methoxyfenozide Chlorantraniliprole	**$16-37**
	Total Chemical Cost, Current Scenario	**$12-16**	*Total Chemical Cost, Mitigation Scenario*	**$16-37**
			Potential Additional Yield and Quality Losses from Cucumber Beetles, Aphids, Thrips, and other Hemipterans	***Unknown, but likely very large. Up to 100% total losses***
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($0-25) + Large Yield Loss**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. It is possible that some systemic insecticides (i.e., neonicotinoids) applied via soil drench might provide efficacy against aphids and thrips. MRD (2009-2013) indicate that soil drench applications are made to cucurbits, but only foliar alternatives were considered for this analysis.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios and in situations where control is not possible without MHAT insecticide applications, significant yield loss would be expected if no applications were made of this product.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. Due to the extended period of bloom for cucurbits, it is unlikely that delayed timing would provide adequate protection for direct-feeding pests. For mites or aphids, because of the potential for large and sudden outbreaks, exceedance of threshold levels could also sometimes necessitate miticide applications during bloom. For the other listed pests, and in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures.

OPTION 2: RISK-BASED LIMITATIONS ON PESTICIDE USAGE

Table 38 compares the current chemical controls used by pumpkin growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal.

Certain active ingredients may be available to growers if they are applied below rates that are moderately harmful and acutely toxic to pollinators (Table 38). For example, acetamiprid may be used to control cucumber beetles and indoxacarb may be used to control lepidopteran pests.

While substitution costs for control of Lepidopteran pests would remain mostly unchanged, the large yield losses associated with aphids, mites, and cucumber beetles would be eliminated, due to the availability of acetamiprid for control of these pests during bloom. Potential yield losses are still possible from thrips and Hemipterans, though applications targeting these pests during bloom periods account for a relatively small proportion of acreage.

Table 38: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Pumpkin Option 2

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Coleoptera	Bifenthrin Lambda-Cyhalothrin	**$6-7**	Acetamiprid	**$20**
Lepidoptera	Flubendiamide Indoxacarb Methomyl Methoxyfenozide	**$12-16**	Methoxyfenozide Chlorantraniliprole	**$16-37**
Aphids	Endosulfan Cyfluthrin Imidacloprid Thiamethoxam	**$3-8**	Acetamiprid	**$20**
	Total Chemical Cost, Current Scenario	**$21-31**	*Total Chemical Cost, Mitigation Scenario*	**$56-77**
			Potential Additional Yield and Quality Losses from Thrips and other Hemiptera	**Unknown**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($25-56) + Significant Yield Losses**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

UNCERTAINTY: GROWER CHANGES POLLINATOR PRACTICES.

The blossoms of cucurbit crops require commercial insect pollination services during the bloom period to produce a viable crop. Although some pollination occurs with native pollinators, contracted honey bees are responsible for the majority of cucurbit pollination.

Squash (California, Florida, Michigan)

When taken in total on a seasonal and national basis, MHAT insecticides constitute approximately 83% of all insecticide treated acres for squash (MRD, 2009-2013). The top MHAT insecticides used in California squash include bifenthrin, acetamiprid, and zeta-cypermethrin, with 11,337, 7,835, and 3,262 TAT during bloom from 2009-2013, respectively (Table 39). The University of California, Davis (2014) recommends bifenthrin and acetamipird as foliar sprays to control whiteflies. Bifenthrin, which was the leading insecticide applied to California squash from 2009-2013, was applied to approximately 37 % of all California squash acreage during that time period. Up to 100% of California squash acreage was treated with an MHAT insecticide during vining to harvest, assuming that the same area is not treated with multiple active ingredients (AIs) during this period. Therefore, BEAD concludes that the total California squash acreage treated during bloom with any MHAT chemical is no less than 37% and could be up to 100% in an upper-bound scenario, when all acreage treated with MHAT chemicals during bloom are added.

Table 39: California Squash Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
ACETAMIPRID	7,835	90%
AZADIRACHTIN	2,225	100%
BIFENTHRIN	11,377	81%
DINOTEFURAN	2,618	98%
ESFENVALERATE	821	20%
FENPROPATHRIN	818	100%
MALATHION	902	38%
METHOMYL	1,494	100%
OXAMYL	1,459	45%
PERMETHRIN	975	86%
PYRETHRINS	1,965	78%
THIAMETHOXAM	1,433	42%
ZETA-CYPERMETHRIN	3,262	64%

[1]*For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'vining to harvest' which is indeterminate for cucurbits.*
[2]*For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages.*
Source: MRD, 2009-2013. Numbers may not add due to rounding.

MRD indicate that coleopteran and hemipteran species are the most important pests in terms of total acres treated during bloom for California squash (Table 40). The first column indicates the importance of vining to harvest applications for controlling specific pests. The second column indicates the importance of this pest during vining to harvest relative to other pests. Treatments targeting hemipteran pests, such as aphids and squash bugs, constitute 64% of treated acres during vining to harvest. Furthermore, treatments targeting hemipteran pests account for 46% of all treated acres by target pest.

Table 40: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, California Squash, 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Percent of Total Bloom Time Treated Acres by Target Pest
Coleoptera	44%	8%
Hemiptera	64%	46%
Mites	89%	17%
Lepidoptera	96%	15%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.

[1]Of all pesticide applications that were made to strawberries throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.

[2]This number represents the percentage of bloom time pesticide applications on California squash across all active ingredients that target each pest listed in the Pest column.

Pest pressures and preferred treatment options in Florida squash are markedly different than in California squash. The two most dominant MHAT insecticides in Florida squash production are dinotefuran and permethrin, which were used on over 9,000 and 6,000 acres, respectively, during vining to harvest from 2009-2013. Insecticides that were used on over 2,000 acres from 2009-2013 include abamectin, acephate, malathion, methomyl, and pyrethrins.

MRD suggest that the overall percentage of Florida squash treated for most of these chemicals is high. Endosulfan, Azadirachtin, Cyhalothrin-Lambda, Spinetoram, and Zeta-Cypermethrin constitute that largest proportion of vining to harvest acres treated as a percent of total acres treated at 100% (Table 41). All MHAT insecticides had over 20% of vining to harvest treated as a percent of TAT. The overall percentage treated for MHAT chemicals is high. Up to 100% of Florida squash acreage is treated with an MHAT insecticide during vining to harvest, assuming that the same area is not treated with multiple AIs during this period. In estimating a percentage of the total Florida squash acreage treated during vining to harvest with one or more MHAT chemicals, BEAD concludes that it would be a minimum of 27% and a maximum of 100%.

Table 41: Florida Squash Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
ABAMECTIN	4,272	40%
ACEPHATE	2,065	36%
AZADIRACHTIN	555	100%
CYHALOTHRIN-LAMBDA	1,185	100%
DINOTEFURAN	9,372	47%
ENDOSULFAN	1,165	100%
ESFENVALERATE	1,720	43%
MALATHION	4,539	43%
METHOMYL	2,263	38%
PERMETHRIN	6,389	45%

PYRETHRINS	2,112	52%
SPINETORAM	1,896	100%
THIAMETHOXAM	666	24%
ZETA-CYPERMETHRIN	1,111	100%

[1]For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'vining to harves' which is indeterminate for cucurbits.
[2] For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages.
Source: MRD, 2009-2013. Numbers may not add due to rounding.

Proprietary data indicate that lepidopteran pests, hemipteran pests, and thrips are the most important pests in terms of total acres of Florida squash treated during bloom (Table 42). The first column indicates the importance of bloom stage applications for controlling this type of pest. The second column indicates the importance of this pest during vining to harvest relative to other pests. Overall, over 30% of treatments occurred during vining to harvest for all pests listed in Table 42. Treatments for lepidopteran pests during bloom constitute 48% of all treatments for those pests. Furthermore, Lepidopeteran pests and hemipteran pests are the most important insect pests in Florida squash, as treatments for these pests represent about 20% and 21% of all pesticide treatments acreage during bloom, respectively.

Table 42: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, Florida Squash, 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
Lepidoptera	48%	20%
Thrips	37%	3%
Coleoptera	35%	4%
Mites	39%	2%
Hemiptera	40%	21%
Leafminer	36%	3%

Source: Market Research Data, 2009-2013. Numbers may not add due to rounding.
[1]Of all pesticide applications that were made throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.
[2]This number represents the percentage of bloom time pesticide applications on apples across all active ingredients that target each pest listed in the Pest column.

For Michigan squash, Endosulfan, Esfenvalerate, Permethrin, Carbaryl, and Cyfluthrin constitute the largest proportion of vining to harvest acres treated as a percent of total acres treated at up to 71% (Table 43). All MHAT insecticides had over 10% of vining to harvest treated as a percent of TAT. The overall percentage treated for MHAT chemicals is high.

Table 43: Michigan Squash Proportion of Total Acres Treated during Bloom Stages with Insecticides Moderately or Highly Acutely Toxic to Bees, 2009-2013

Active Ingredient	Total Acres Treated, Bloom Stages [1,2]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]

CARBARYL	4,986	58%
CYFLUTHRIN	3,983	71%
CYHALOTHRIN-LAMBDA	1,202	30%
ENDOSULFAN	5,809	75%
ESFENVALERATE	7,909	54%
IMIDACLOPRID	901	10%
PERMETHRIN	7,151	60%
PYRETHRINS	909	56%
ZETA-CYPERMETHRIN	1,411	45%

[1]For each active ingredient, this represents the total acreage treated during bloom stages. Bloom stages include 'vining to harves' which is indeterminate for cucurbits.
[2] For each active ingredient, this represents the relative proportion of a chemical's total seasonal usage that occurs during bloom stages.
Source: MRD, 2009-2013. Numbers may not add due to rounding.

Proprietary data indicate that mites, Hemipteran pets, and thrips are the most important pests in terms of total acres of Michigan squash treated during bloom (Table 44). The first column indicates the importance of bloom stage applications for controlling this type of pest. The second column indicates the importance of this pest during vining to harvest relative to other pests.

Table 44: Percentages of Applications Targeting a Particular Pest, Bloom Stages Only, Michigan Squash, 2009-2013

Pest	Percent of Total Acres Treated whose Application Occurred During Bloom Stages[1]	Bloom Stage Acres Treated as a Percent of Total Acres Treated [2]
Coleoptera	52%	20%
Hemiptera	69%	15%
Lepidoptera	46%	0%
Mites	100%	0%
Thrips	60%	0%

Source: Market Research Data, 2009-2013.. Numbers may not add due to rounding.
[1]Of all pesticide applications that were made throughout the year—including before, during, and after the bloom stage—this number represents the percentage of total acres treated that were made during the bloom stage for each pest listed in the Pest column.
[2]This number represents the percentage of bloom time pesticide applications on apples across all active ingredients that target each pest listed in the Pest column.

OPTION 1

A) USE OF AN ALTERNATIVE PRODUCT OR COMBINATION OF PRODUCTS THAT ARE APPLIED FOLIARLY BUT DO NOT CONTAIN AN ACTIVE INGREDIENT THAT IS MODERATELY OR HIGHLY ACUTELY TOXIC TO BEES

Table 45 compares the current chemical controls used by squash growers to chemical controls which would be the likely leading alternatives adopted under the proposed mitigation. As was discussed previously, the percentage of overall treatments with MHAT insecticides that occur during bloom is relatively high, with up to 100% of squash acreage treated during bloom for important pests in California and Florida.

For growers that use MHAT chemicals during bloom stages, there will be expected impacts from the increased cost of switching to non-MHAT insecticide treatments targeting Lepidopteran pests. Substitution costs for Lepidopteran pests are relatively low and impacts would not affect all growers, since some squash growers are already using non-MHAT materials to target these pests. More critically, under mitigation option 1, there are no alternative registered chemicals that are effective for control of beetles, aphids, whiteflies, thrips, mites, or other hemipterans such as plant bugs and stink bugs. For growers affected by these pests, substantial yield losses could be expected. Such losses could be further compounded by the inability to control pests that vector viral diseases (such as cucumber mosaic virus, etc.), and in some instances, failure to mitigate such risks could lead to a total loss of production.

Table 45: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Squash Option 1

Target Pest(s)	**Current Chemical Controls**		**Expected Chemical Controls Under Mitigation**	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Lepidoptera	Bifenthrin Zeta-cypermethrin	**$5-7**	Methoxyfenozide Chlorantraniliprole	**$14-29**
	Total Chemical Cost, Current Scenario	**$5-7**	*Total Chemical Cost, Mitigation Scenario*	**$14-29**
			Potential Additional Yield and Quality Losses from Cucumber Beetles, Aphids, Whiteflies, and other Hemipterans	***Unknown, but likely very large. Up to 100% total losses***
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($7-22) + Large Yield Loss**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. It is possible that some systemic insecticides (i.e., neonicotinoids) applied via soil drench might provide efficacy against aphids and thrips. MRD (2009-2013) indicate that soil drench applications are made to cucurbits, but only foliar alternatives were considered for this analysis.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For the pests being targeted in these scenarios and in situations where control is not possible without MHAT insecticide applications, significant yield loss would be expected if no applications were made of this product.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. Due to the extended period of bloom for cucurbits, it is unlikely that delayed timing would provide adequate protection for direct-feeding pests. For mites or aphids, because of the potential for large and sudden outbreaks, exceedance of threshold levels could also sometimes necessitate miticide applications during bloom. For the other listed pests, and in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures.

OPTION 2: RISK-BASED LIMITATIONS ON PESTICIDE USAGE

Table 46 compares the current chemical controls used by squash growers to chemical controls which would be the likely leading alternatives adopted under option 2 of the revised mitigation proposal. Certain MHAT active ingredients may be available to growers if they are applied below rates that are moderately harmful and acutely toxic to pollinators (Table 46). For example, acetamiprid may be used to control cucumber beetles and indoxacarb may be used to control lepidopteran pests.

.

While substitution costs for control of Lepidopteran pests would remain mostly unchanged, costs for other pests would increase relative to option 1, but this is offset by mitigation of yield losses. The large yield losses associated with coleoptera, mites, and aphids/whiteflies would be eliminated, due to the availability of acetamiprid for control of these pests during bloom. Potential yield losses are still possible from thrips and Hempiteran pests, though applications targeting these pests during bloom periods account for a relatively small proportion of acreage.

Table 46: Comparison of Current Control Measures to Possible Control Measures that would be Allowed under the Proposed Mitigation, Squash Option 2

Target Pest(s)	Current Chemical Controls		Expected Chemical Controls Under Mitigation	
	Active Ingredient	**$/A**	**Active Ingredient**	**$/A**
Coleoptera	Esfenvalerate Carbaryl Bifenthrin	**$5-8**	Acetamiprid	**$29**
Mites	Abamectin Dicofol Bifenthrin	**$7-13**	Spiromesifen Bifenazazte	**$27-49**
Lepidoptera	Bifenthrin Zeta-cypermethrin	**$5-7**	Methoxyfenozide Chlorantraniliprole	**$14-29**
Aphids/Whiteflies	Endosulfan Cyfluthrin Imidacloprid Thiamethoxam	**$3-8**	Acetamiprid	**$20**
	Total Chemical Cost, Current Scenario	**$20-36**	*Total Chemical Cost, Mitigation Scenario*	**$90-127**
			Potential Additional Yield and Quality Losses from Thrips and other Hemiptera	**Unknown**
Total Net Impacts on Grower in New Scenario vs. Status Quo ($/A)				**($54-107) + Possible Significant Yield Losses**

Numbers may not add due to rounding. Source: MRD, 2009-2013. Prices of active ingredients represent 2009-2013 5-year average.

UNCERTAINTY: GROWER CHANGES POLLINATOR PRACTICES.

The blossoms of cucurbit crops require commercial insect pollination services during the bloom period to produce a viable crop. Although some pollination occurs with native pollinators, contracted honey bees are responsible for the majority of cucurbit pollination.

CUCURBIT SUMMARY

Because cucurbit crops have a long, indeterminate period of bloom, large impacts are projected for restrictions that preclude usage of MHAT insecticides to control a variety of key pests. Yield losses are projected under mitigation option 1, due to no available alternatives for control of pests such as aphids, whiteflies (which also are an important vector of a number of diseases in cucurbits), thrips, and stink bugs, as well as coleopteran pests such as cucumber beetles. While substitutions are available under mitigation option 2 for control of aphids, whiteflies, and coleopterans, the lack of available efficacious alternatives for control of thrips and stink bugs is likely to still drive potentially significant yield losses due to damage from these pests for long periods of time while cucurbit crops continue to bloom. Estimates of total cost impacts were not calculated, due to the uncertainty of the magnitude of these potential yield losses, which would be present under both mitigation options.

SEED CROPS

SUNFLOWERS

OVERVIEW

The primary producing sunflower states in terms of acres grown include North Dakota (697,800 acres grown) and South Dakota (570,000 acres grown) (USDA, 2014). These two states are the top producers for both non-oil and oil type sunflowers. Sunflower production in North Dakota and South Dakota account for 74% of sunflower acres grown in the U.S. Blooming typically lasts through the summer months and can extend into early fall.

North Dakota (2014) has one of the most robust Managed Pollinator Protection Plans (MP3) in the country. Although there are no limitations outlined in this plan that would further restrict pesticide applications during bloom time, it does request that pesticide applicators notify beekeepers of impending pesticide applications at least 48 hours prior to application. This would allow beekeepers time to cover or move hives—it also allows time for beekeepers to work with pesticide applicators in making pesticide applications at times of the day when bees are less active. In supporting this communication, North Dakota has created an online interactive and searchable map that allows pesticide applicators to identify registered bee yards. South Dakota is still in the process of designing an MP3 for their state, but it will closely resemble the MP3 created by North Dakota. BEAD has received information indicating that most sunflower growers in North Dakota do not utilize commercial pollination services, though placement of bees for honey production is very common and it is likely that honeybee foraging does have a positive impact on seed yield (NDGGA, Pers. Comm.). However, USDA-ERS data indicate that sunflowers are the second largest source of pollination service fee income in the U.S. (second to almonds), which indicates that a significant number of growers, (possibly in areas outside of the Dakotas), do rely on commercial pollination (Bond et al., 2014).

USAGE OF MHATS ON SUNFLOWERS

When taken in total on a seasonal and national basis, MHAT insecticides constitute nearly 100% of all insecticide treated acres for sunflowers (MRD, 2009-2013). Market research data for sunflowers cannot be refined down to bloom time applications. Therefore this analysis considers applications across the entire growing season. However, it should be noted that the main period of activity for control of seed weevils occurs during sunflower bloom (Peng, et al., 1997). Furthermore, depending on timing, chemical control for stem weevils may also overlap considerably with sunflower bloom, depending on when populations begin to exceed economic thresholds (Knodel and Charlet, 2002). MHATs account for approximately 25% of the total sunflower area treated across the U.S. On average, the leading MHAT chemicals used in North Dakota and South Dakota were esfenvalerate and lambda-cyhalothrin across all pests (MRD, 2009-2013).

Top insecticide usage on sunflowers is for the treatment of weevils (920,600 total acres treated on average, 2009-2013). Other common insects targeted include sunflower moths, grasshoppers, and cutworms. Currently, esfenvalerate and lambda-cyhalothrin are the leading chemicals used to control weevils on sunflowers. Esfenvalerate is used to treat approximately 480,500 acres, or 8% of total sunflower acres treated annually across all chemicals. Lambda-cyhalothrin is used to treat approximately 275,500 sunflower acres, or 4% of total acres treated annually across all chemicals. Although these numbers represent usage across all crop stages, it is likely that treatments for weevils are occurring during bloom time as they are pollen feeders and pollen is most available during bloom.

Option 1

A) Use of an alternative product or combination of products that are applied foliarly but do not contain an active ingredient that is moderately or highly acutely toxic to bees

In the case of weevils, there are no chemical alternatives available that are not considered MHAT to bees. If usage of insecticides is prohibited during bloom periods, extensive yield losses from weevils would be expected for growers that use commercial pollination services.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. No products are available to control weevils that are not applied foliarly.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For growers targeting weevils that are not able to apply MHAT insecticides, significant yield loss would be expected if esfenvalerate or lambda-cyhalothrin were not applied.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. For weevils, in situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures.

Option 2: Risk-Based Limitations on Pesticide Usage

No chemical alternatives are available for use during bloom periods. If usage of insecticides is prohibited during bloom periods, extensive yield losses from weevils would be expected for growers that use commercial pollination services.

Sunflower Summary

Overall, substantial yield losses from weevil damage may occur in the absence of MHAT insecticides as non-MHAT insecticides do not provide the proper control for this pest under either mitigation option. Growers facing these impacts who make use of contracted pollination services would be expected to incur large losses in yields. However, it is unknown how many sunflower growers utilize contract pollination services as opposed to those who simply benefit by bee presence near their fields.

Alfalfa Seed

The primary producing alfalfa seed states in terms of acres grown include California, with almost 40,000 acres grown, Washington, with about 11,000 acres grown, and Wyoming, Idaho and Montana, all with between 6,000 and 7,000 acres grown in 2012 (USDA, 2014). These five states are the top producers of alfalfa seed, and accounted for 80% of the acreage of alfalfa grown for seed, and 85% of the alfalfa seed produced in 2012.

California's Code of Regulations, Title 3, currently contains some provisions for pollinator protection that include notifying beekeepers when toxic pesticides will be applied and restricts applications in citrus areas during bloom of certain pesticides that are toxic to bees (Cal DPR, 2104). However, only the notifications, not the bloom-time restrictions, apply to seed crops. While most seed growers in the Pacific Northwest make use of leafcutter bees or native populations of alkali bees, California seed growers rely extensively on commercial honeybee pollination services (Hirnyck et al., 2005), though the extent of this reliance relative to other species is unknown.

Usage of MHATs on Alfalfa Seed

Market research (MRD) data for alfalfa cannot be refined down to evaluate usage on seed production acreage. Furthermore, even for alfalfa produced for hay, the data cannot be refined to bloom time applications. Because alfalfa bloom is indeterminate and fields remain in bloom for long periods of time, this analysis is qualitative in nature.

Mid-season management of aphid pests and plant bugs (*Lygus spp.*) is problematic given the long indeterminate blooming period for alfalfa and similar flowering forage crops. Synthetic pyrethroid insecticides are the most commonly recommended materials for Lygus control on seed alfalfa (Hirnyck et al, 2005). Further, MRD (2010-2014) indicate that broad-spectrum organophosphate and synthetic pyrethroid insecticides are the leading insecticides used for Lygus and aphid control on alfalfa. But it should be noted that this is not specific to alfalfa grown for seed. Novaluron is a non-MHAT insecticide that is commonly used to target Lygus in other crops, including cotton (MRD 2010-2014), but season-long efficacy for use in seed alfalfa is unknown. Furthermore, it is unknown how many, if any efficacious materials would be available for aphid control.

Option 1

A) Use of an alternative product or combination of products that are applied foliarly but do not contain an active ingredient that is moderately or highly acutely toxic to bees

There are no chemical alternatives available that are not considered MHAT to bees. If usage of insecticides is prohibited during bloom periods, extensive yield losses from aphids and Lygus could be expected for growers that use commercial honeybee pollination services.

B) USE A PRODUCT THAT IS NOT APPLIED FOLIARLY. No products are available to control aphids or Lygus that are not applied foliarly.

C) "OPT" TO MAKE NO APPLICATION(S) OF THE CHEMICAL(S). For growers targeting aphids or Lygus that are not able to apply MHAT insecticides, significant yield loss would be expected insecticides were not applied.

D) MAKE THE APPLICATION(S) OUTSIDE THE TIMEFRAME WHEN FLOWERING HAS ONSET TO WHEN FLOWERING IS COMPLETE. In situations where adequate control is not possible without bloom-time insecticide applications, significant yield losses would be expected if applications were made outside of bloom time, due to control failures.

Option 2: Risk-Based Limitations on Pesticide Usage

Other than novaluron for control of Lygus, no chemical alternatives are available for use during bloom periods. If usage of insecticides is prohibited during bloom periods, extensive yield losses from aphids and Lygus would be expected for growers that use commercial pollination services.

ALFALFA SEED SUMMARY

Overall, substantial yield losses from Lygus bug and aphid damage may occur in the absence of MHAT insecticides as non-MHAT insecticides do not provide adequate control for these pests. Growers facing these impacts who make use of contracted pollination services would be expected to incur large losses in yields. However, it is unknown how many seed growers outside of California utilize contract pollination services as opposed to those who utilize leafcutter or alkali bees cultured on-site, or simply benefit by volunteer bee presence near their fields.

CONCLUSIONS

In assessing likely impact of proposed restrictions, BEAD assessed both the substitution costs of non-toxic alternative insecticides for bloom time use as well as the likelihood and extent of yield losses for cases where alternatives are either inadequate or unavailable. On the whole, the magnitude of projected impacts is driven by the likelihood of yield losses. While pesticide substitution costs can be significant for some of the crops, these impacts are dwarfed by any potential loss of crop yield (or significant reductions in crop quality) that would result from the inability to control specific pests during bloom. BEAD's analysis concluded that yield losses were likely for the crops with long periods of indeterminate bloom, and on the whole, extended bloom times were the best predictor of high impacts driven by yield losses.

Under option 1, large yield losses were projected for east coast pome and stone fruits, strawberries, caneberries, all cucurbits, and all seed crops, including sunflowers and alfalfa seed. Moderate yield losses, based somewhat on uncertainty due to qualitative analyses were also projected for blueberries and cranberries. Table 47 summarizes both the likely substitution costs and the projected yield losses for blooming crop cases where all MHAT insecticides are prohibited during bloom times.

Table 47: Summary of Impacts for Mitigation Option 1: All MHAT Insecticides Prohibited During Bloom Time

Crop	Percent of Acreage Affected	Increased Cost of Non-MHAT Alternatives ($/acre)	Expected Yield Loss	Low-Medium-High Impact?
Almonds	<10%	$79	None expected	L
Pome/Stone Fruits--East	40-100%	$65-96	10-20% losses due to plum curculio	H
Pome/Stone Fruits--West	40-50%	$7-31	None expected	L-M
Strawberries	<20%	$48	Large losses from aphids, thrips, and Lygus bugs	H
Caneberries	100%	$28-65	Large losses from aphids and thrips	H
Blueberries	Unknown	Unknown	Some losses possible from thrips	M
Cranberries	Unknown	Unknown	Some losses possible from black vine weevils in the Pacific Northwest	M
Cantaloupes	100%	$0-18	Large losses from aphids/whiteflies, thrips, and stink bugs	H
Cucumbers	85%	$0-25	Large yield losses from aphids, thrips, and mites. No alternatives for cucumber beetles in MI	H
Pumpkins	10%	$0-25	Large losses from aphids/whiteflies, thrips, beetles, and stink bugs	H
Squash	100%	$7-22	Large losses from aphids/whiteflies, beetles, thrips, and stink bugs	H
Alfalfa Seed	Unknown	Unknown	Large yield losses from Lygus and aphids	H
Sunflowers	Unknown	Unknown; No alternatives for stem and seed weevil complex	Very large yield losses from seed-stem weevils, up to 100%	H

Under option 2, large yield losses were obviated, with the exception of seed crops, and cucurbits for which adequate effective insecticides remain unavailable to control major bloom time pests such as Lygus and aphids on alfalfa seed, the weevil complex on sunflowers, and thrips and stink bugs on cucurbit crops. Yield losses based on uncertainties are still projected for strawberries, due to uncertainty about plant bug control during the long periods of indeterminate bloom. However, yield loss projections are no longer expected to be significant for pome and stone fruits, blueberries, cranberries and caneberries, and the impacts expected under option 2 for these crops are mostly driven by pesticide alternative substitution costs. Table 48 summarizes the likely impacts for blooming crops under mitigation option 2, which uses application rates to determine risks to bees, and allows for usage of materials such as acetamiprid, indoxacarb, bifenazate, etc.

Table 48: Summary of Impacts for Mitigation Option 2: Usage allowed for materials that are below OPP's LOC for adult bee acute toxicity

Crop	Additional AI's Made Available	Increased Cost of Alternatives ($/acre)	Expected Yield Loss	Low-Medium-High Impact?
Almonds	Acetamiprid	$53	None expected	L
Pome/Stone Fruits--East	Acetamiprid	$15-46	None expected	L
Pome/Stone Fruits--West	Acetamiprid	$0-24	None expected	L
Strawberries	Acetamiprid, Bifenazate	$0-52	Some losses possible from Lygus bugs	M-H
Caneberries	Acetamiprid	$0-53	None expected	L
Blueberries	Acetamiprid	Unknown	None expected	L
Cranberries	Indoxacarb, Acetamiprid	Unknown	None expected	L
Cantaloupes	Acetamiprid	$22-76	Some yield losses from thrips, and Hemipterans	M-H
Cucumbers	Acetamiprid	$0-87	Some yield losses from thrips and Hemipterans	M-H
Pumpkins	Acetamiprid	$25-56	Some yield losses from thrips and Hemipterans	M-H
Squash	Acetamiprid	$54-107	Some yield losses from thrips and Hemipterans	M-H
Alfalfa Seed	Acetamiprid, Novaluron	Unknown	Some yield losses possible from Lygus and aphids	H
Sunflowers	NONE	Unknown	Very large yield losses from seed-stem weevils, up to 100%	H

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APPENDIX 1: MHAT Insecticides/Miticides Proposed to be Prohibited Under Mitigation

Option 1:

Abamectin, Acephate, Acetamiprid, Aldicarb, Amitraz, Azadirachtin, Bifenazate, Bifenthrin, Carbaryl, Carbofuran, Chlorethoxyfos, Chlorfenapyr, Chlorpyrifos, Clothianidin, Cyantraniliprole, Cyfluthrin, Cyhalothrins (all isomers), Cypermethrins (all isomers), Deltamethrin, Diazinon, Dicrotophos, Dimethoate, Dinotefuran, Emamectin Benzoate, Endosulfan, Esfenvalerate, Ethoprop, Fenpropathrin, Fipronil, Imidacloprid, Indoxacarb, Malathion, Methomyl, Naled, Oxamyl, Permethrin, Phorate, Phosmet, Profenofos, Pyrehtrins, Pyridaben, Rotenone, Spinetoram, Spinosad, Sulfoxaflor, Tefluthrin, Thiamethoxam, Tolfenpyrad.